Bern University of Applied Sciences
Berner Fachhochschule
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Schweizerische Hochschule
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Agronomy / International Agriculture

Bachelor Thesis

Response-Inducing Sustainability Evaluation (RISE) Model to Assess Sustainability of Ethiopian Farming Systems

A Case Study of

Livestock Water Productivity Improvement
(CPWF Project 37)

in

Farta-Fogera districts, Blue Nile River Basin,
Northern Ethiopia

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To Wagnew Ayalneh,
and all those who, like him,
are working for a better life
for the Ethiopian farmers.

Background

The Challenge Program on Water and Food (CPWF)[1] is a global research program attempting to sustainably meet demands for food production over the next few decades without increasing use of agricultural water. Achieving this goal demands increased water-use efficiency or agricultural water productivity (WP). The International Livestock Research Institute (ILRI) and several partners are conducting research aimed at understanding how livestock interact with water resources and how livestock can be managed so that animal production depletes and contaminates minimal amounts of water and contributes to increase WP.

Evidence suggests that in Sub-Saharan Africa, water use by livestock can be reduced by more than 50% while maintaining or increasing current levels of production (IWMI 2007). At the same time, appropriate management practices can greatly reduce water and land degradation. Research indicates that integrating investments in livestock and agricultural water development will result in higher returns on investments and increased profitability and sustainability (IWMI 2007).

Farta and Fogera woredas[2], lying on the Eastern shore of Lake Tana at the source of the Blue Nile River, constitute a key site where CPWF research has focused on livestock-water productivity (LWP). CARE-Ethiopia, one of ILRI's partners, operates a large INRM development project in the area. The research on livestock and water has made an implicit assumption that lack of access to adequate quality water constrains food production livelihoods and that farmers' efforts to procure and use essential water resources contributes to environmental degradation. The purpose of this study will be to determine the relative importance of access to water as a factor contributing human well being in comparison with other livelihood assets.

This study area spans an elevational gradient from about 1700 to 3700 m (ASL) and includes a variety of mixed crop-livestock systems. This study will select two or three communities that reflect this diversity in production. A key characteristic of the study areas is the strong seasonal variation is production. The sites experience a short rainy period from about May to August and a long dry spell for the remainder of the year. Where practical survey data should be gender disaggregated for simple gender analyses.

Objectives

1. The primary objective is to use the RISE model to identify constraints to sustainability in two or three selected communities in the study area. The choice will be made in consultation with field-based partners and the estimated resources needed to complete the work within the time available to the student.

2. To compare water and other key livelihood factors to determine if access to adequate quality water is likely to be an important determinant of sustainability.

3. To work with development partners (probably CARE) to work with communities and identify entry points through which communities might identify options that can help sustainably improve livelihoods.

[1] For more information on the CPWF, refer to www.waterandfood.org or contact ILRI.
[2] A woreda is a local governmental administrative unit of Ethiopia.

Expected results

1. A report describing the application, results and usefulness of the RISE model in the context of the participating communities with special mention of the relative importance of water as a driver of well being and sustainability.

2. Suggestions for interventions for improving livelihoods giving special mention to water management where appropriate.

www.ilri.org
www.shl.bfh.ch
http://rise.shl.bfh.ch

Drawing page iii: Farmer on the way to the Zuquala Mountain rejoining monastery on top of the holly volcano.

Drawing and all pictures are from the author.

Table of content

Abbreviations and Acronyms

ARARI	Amhara Regional Agricultural Research Institute
ASL	above sea level
CGIAR	Consultative Group of International Agriculture Research, www.cgiar.org
CPWF	Challenge Program on Water and Food, www.waterandfood.org
EPRDF	Ethiopian People's Revolutionary Democratic Front
GDP	Gross Domestic Product
GTZ	German Agency for Technical Cooperation, www.gtz.de
HIPC	Highly Indebted Poor Countries
IMF	International Monetary Fund
INRM	Integrate Natural Resource Management
ILRI	International Livestock Institute Research Institute, www.ilri.org
IPMS	Improving Productivity and Market Success of the Ethiopian Farmers, www.ipms-ethiopia.org
IWMI	The International Water Management Institute, www.iwmi.cgiar.org
NGO	Non Governmental Organisation
PA	Peasant Association
RISE	Response Inducing Sustainability Evaluation, www.shl.bfh.ch/?id=425
SCA	Swiss College of Agriculture, www.shl.bfh.ch
TLU	Tropical Livestock Unit = 250 kg living weight = 0.5 LAU (Livestock Animal Unit, used for animals in modern countries)
WF	Working Force from RISE, age corrected working person (WP) (no unit)

Abstract

The pressure on the arable land in the Ethiopian Highlands is high due to the natural resources being constantly reduced and livestock- and water productivity being insufficient to meet actual and future food demands of the growing population. This study is embedded in the projects of the ILRI (International Livestock Research Institute) who is committed to increase livestock- and water productivity and thus alleviate poverty in 12 global benchmarked watersheds. This paper presents the application of the RISE model in a holistic way to assess the sustainability of farming systems by four communities in the Gumara watershed of Lake Tana (Nile / Blue Nile sub-basin).

29 farmers were interviewed in the Farta and Fogara district, East of Lake Tana, using an adapted RISE questionnaire. Based in the upper part of the Blue Nile sub-basin, these farmers represent a sample of the typical farming systems responsible for the major problem of soil fertility depletion and erosion that create land pressure and downstream pollution.

Results revealed major sustainability deficits in economic efficiency (low incomes), social securities (no social insurance and safety nets) and in the management of the nutrient cycle (imbalance due to loss of nutrients and low yields). Other bad indicators of the 29 farms assessed are biodiversity (absent), plant protection and economic stability (no investment). Soil still is a good, available resource but is highly subjected to erosion without there being any countermeasures in place. Moreover, it is exposed to intensive cultivation and overgrazing. The farmers perceive water as a resource that is available on a yearly basis. RISE, however, has determined that it is a highly polluted resource due to animals entering the water bodies. This has a detrimental impact both on the health of humans and livestock. High water run-offs and nutrient losses considerably lower yields. As a result, there is a high potential to increase water productivity.

The RISE approach could reveal a number of intervention points on how sustainability deficits can be addressed. The analysis of results and informal interviews revealed three principal entry points that are highly efficient concerning the increased effectiveness of efforts that are already being made. The first step is to support farmers in their process of land consolidation and, as a result, considerably increase labor efficiency, farm management and motivation. Secondly, society should be organized in such a way that communal free grazing areas are managed to avoid high levels of erosion and increase fodder- and thus livestock and water productivity. Thirdly, market prices should be stabilized to allow farmers to escape the vicious poverty spiral.

This study discusses several alternatives for the implementation of these three strategies as well as five other secondary entry points and enhances negative findings detected by the RISE tool. These measures helping the three main entry points are: irrigation systems to reduce the variation in water availability, applied agricultural techniques to keep soil cover and increase biodiversity, fodder production, herd management and group dynamics to stimulate change. The feedback to farmers, local NGOs and centers (CARE, GTZ, ARARI) could validated both the RISE results and the three main intervention points. Water management and good farming practices are obvious means of improvement of which there is already good awareness. They are, however, not yet fully implemented. Their efficient broad and necessary realization will only be possible after implementation of the first three entry points mentioned above.

Photo 1: Overgrazed free grazing area, large plains between Addis and Bahir Dar, 2/20/2008.

1. Context

The objective of this section is to present players and to define necessary concepts in order to understand the complex set of interactions between farming systems, society and resources.

2.1 Introduction

The growing population increases the demand for food and water. This pressure on resources requires an improved management of food production and of the water balance due to more food having to be produced with less water. This is the core concept of the Challenge Program on Water and Food (CPWF) launched by the Consultative Group of International Agriculture Research (CGIAR) in 2004. The International Livestock Research Institute (ILRI), supported by the CGIAR, participates in this program to alleviate poverty by improving livestock productivity. This program located 9 benchmark basins in the poor parts of the world. The Nile basin is the biggest area, where the Blue Nile River flows into the Nile River in Sudan, contributing approx. 60% of its water. The source of the Blue Nile River is Lake Tana in Northern Ethiopia, where livestock concentration and land degradation are high. The number of livestock concentration in this Nile basin is the highest in Africa (Amede et al. 2008).

To better understand the overall interactions that lead farmers to keep a certain kind of livestock and its impact on water management, ILRI is interested in assessing the sustainability of the farming system of Northern Ethiopia using the RISE model (Response Inducing Sustainability Evaluation) of the Swiss College of Agriculture (SCA). The RISE model allows the scanning of all aspects of farming systems to determine the sustainability of the techniques used at farm level (See Chapter 3.7).

In this study RISE model has been applied to 29 farmers situated in lowland- (1850m ASL) and upland areas (2400m ASL) of the East region of Lake Tana, Northern Ethiopia. The study area is located in the Gumara watershed and belongs to the poorest agricultural part of Ethiopia, where poverty and pressure on the land destroy biodiversity and soil resources and where water productivity of the 1200 mm to 1500 mm yearly monomodal rainfall is very low. Erosion, as consequence of the farming management, results in silt that pollutes downstream water, clogs the irrigation systems of Sudan and considerably lowers the soil fertility of the Ethiopian Highlands. Over the past 30 years, food production has declined from 280 to 160 kg/year/capita and food insecurity now affects over half of the country's population (ILRI 2007).

This study aims at determining the relative importance of access to water as a factor that contributes to human well being compared with other livelihood assets. The description of the sustainability of farming systems of two altitudes will demonstrate that the current farming system is unsustainable in general and will focus on water in particular with the following objectives (See ToRs in appendix):

1. Identify constraints to sustainability in two or three selected communities;
2. Determine if access to adequate quality water is likely to be an important factor for sustainability;
3. Identify, together with farmers and development partners, entry points to promote a sustainable improvement of livelihood.

Based on this RISE analysis, informal interviews and feedback from farmers and local NGOs, entry points and recommendations are identified to increase sustainability and water and livestock productivity with a view to improve the livelihood of poor farmers.

2.2 Researches' actors for this study

The mission of the International Livestock Institute Research Institute (ILRI) is to alleviate poverty, hunger and environmental degradation in developing countries by introducing high-quality science into livestock and resources management (ILRI 2006). ILRI works in Africa, Asia and Latin America, with offices in East and West Africa, South and Southeast Asia, China and Central America. ILRI is a non-profit-making and non-governmental organization with headquarters in Nairobi, Kenya, and a second principal campus in Addis Ababa, Ethiopia. They employ 700 staff from approx. 40 countries (mostly from Kenya and Ethiopia), representing 30 different disciplines (ILRI 2006).

ILRI focuses on livestock for the poor because farm animals are an ancient, vital and renewable natural resource. Livestock contributes approx. 80% to the agricultural GDP of the developing countries; 600 million rural poor people rely on livestock for their livelihood (ILRI 2006). Devastating diseases, degraded land- and water resources, scarce livestock feeds and poor access to markets are some of the problems ILRI and its partners are helping to alleviate by developing new knowledge and technological and policy options.

ILRI is lead by 12 professionals concerning relevant research, development and management issues. The institute is supported by the CGIAR (Consultative Group in International Agriculture Research, www.cgiar.org), an association of 60 governments and public- and private-sector institutions supporting a network of 15 agricultural research centres that are working to reduce poverty, hunger and environmental degradation in developing countries. Co-sponsors of the CGIAR are the World Bank, the United Nations Development Programme, the Food and Agriculture Organisation and the International Fund for Agricultural Development. ILRI's expenditure for 2006 was $ 35.4 millions (ILRI 2006). The institute is funded by private-, public- and governmental organization in the north and south, donors, the Kenyan and Ethiopian governments in form of funds and in-kind support.

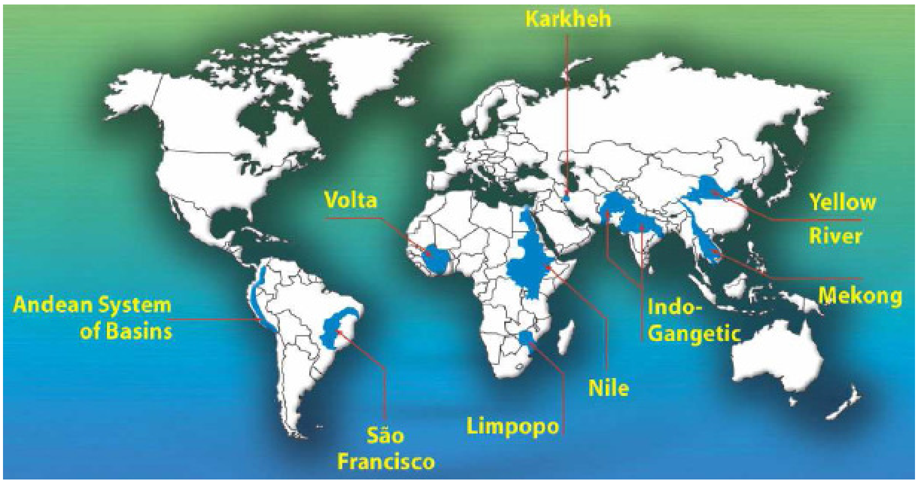


Fig.1: The 9 benchmark basins of the CGIAR challenge program (source: CGIAR, 2007)

In 2003, the CGIAR launched the Challenge Program on Water and Food (CPWF) to alleviate the crisis related to water scarcity and to improve food and livelihoods security. River basin communities are the first to suffer from these threats. This program focuses on 9 benchmark basins worldwide, shown in Figure 1.

The most critical issue facing the world during the next 20 years is to find means of growing more food with less water and without depleting resources. The challenge is to increase water productivity in an environmentally sustainable manner that is socially acceptable in order to meet the needs of the growing population. CPWF formulated its objective in the following question: *Using less water, how can more food be produced, and rural livelihoods be improved, in a manner that is socially acceptable and environmentally sustainable?*

Water is currently at the centre of research because, in developing countries, 70-90% of water is used by agriculture. Five overall themes are driving the research: crop water productivity improvement ("more crop per drop"), water and people in catchments (water management), aquatic ecosystems and fisheries, integrated basin water management systems (upstream and downstream impact management), global and national food and water systems (policies) (ILRI 2006b).

In conjunction with the CPWF and other programs, ILRI organised their projects under research themes such as sustaining water productivity, sustainability of pastoral and agropastoral systems, role of livestock in human health and nutrition, feed productivity to mitigate scarcity and forage diversity through feed genetic resource, for example. This thesis deals with the theme concerning water productivity (PL01), a study registered in the ILRI project 5 on People, Livestock and the Environment, embedded in the PN37 project on Nile Basin Livestock Water Productivity.

CGIAR recognised this Nile watershed as the world's largest. Here, in 2050, there will be a severe water shortage. The amount and quality of this resource affects 160 millions people. Half of the population earns less than $1 per day, the worst affected is Ethiopia. The basin measures approx. 3.1 million km^2 and starts around Lake Victoria; from there, the Nile flows to the Mediterranean Sea (Woldu A, 2004). From Lake Tana in the North of Ethiopia, the Blue Nile flows in a southerly direction and provides 60% of the Nile water when the two rivers join in Sudan.

2.3 Livestock productivity concept of IWMI

The International Water Management Institute (IWMI) closely works with ILRI to develop livestock-water productivity improvement strategies that are explained in the book *Water for food Water for life, A Comprehensive Assessment of Water Management in Agriculture*. The discussions in chapters 5.2.3, 5.3.3 and 5.4.3 relate to some of their following concepts.

Livestock provides meat, milk, eggs, farm power (e.g. for ploughing and transport), blood, hides and manure as energy and nutrient replenishment. It also plays a role in social relations, show prestige and is the main value for insurance. Therefore, animals play an important role in human wealth security and livelihoods. Their sale is a vital strategy tool for increasing incomes and coping with unexpected family expenses (IWMI 2007).

Livestock is dependent on water quantity for its fodder production and on water quality as its drinking resource. The estimated quantity of drinking water consumption per TLU amounts to between 25 and 50 litres per day and increases 100 fold for its feed production (Amede 2008). Water quality is mainly affected by livestock management and livestock access to water bodies whereas run-off is transporting surface substances like silt and organic matter in rivers.

During 2008, the Ethiopian population is increasing at a rate of 2.23% (CIA 2008). As a result, and in parallel to the change in diet, farmers must produce more livestock products to meet demand. The need for water and soil increases and provokes conflicts but also income opportunities. Land pressure leads to the loss of marginal land and to more intensive cultivation. It is, therefore, important to increase livestock and crop/fodder productivity by adapting current farming methods to new ones that produce more using the same surface and less water.

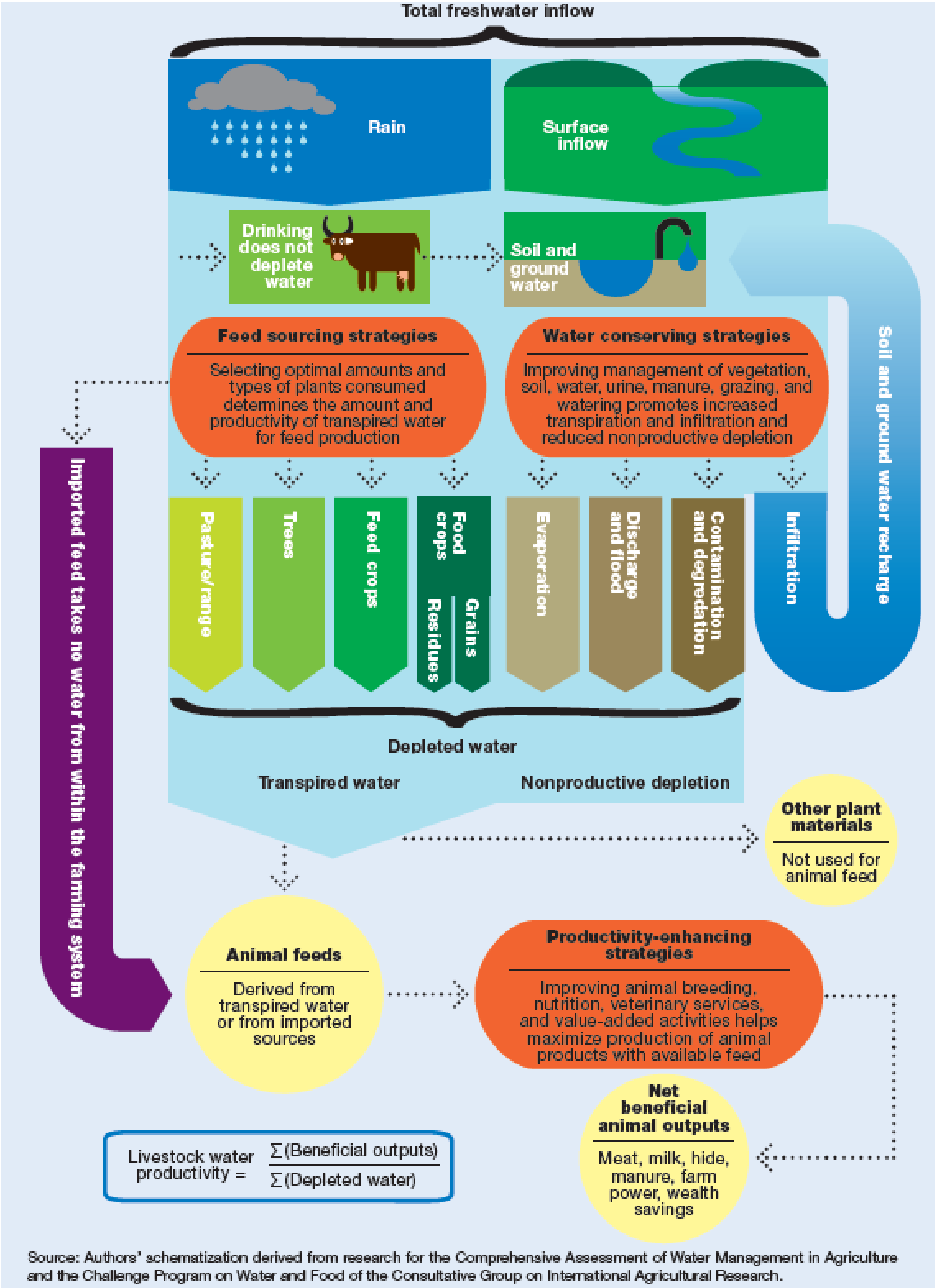


Fig.2: Livestock water productivity framework of IWMI (source: IWMI, 2007)

Livestock water productivity is defined as the ratio of net beneficial livestock-related products and services to the water depleted in producing them (IWMI 2007). IWMI developed the principles of the livestock water productivity illustrated in Figure 2. Regardless of the size of the land area covered, water enters an agricultural system in the form of rain or surface inflow or ground water. Water is depleted or lost through transpiration, evaporation and downstream discharge and cannot be readily used again. Degradation and contamination also deplete water in the sense that the water may be too costly to purify for reuse. Agricultural output depends primarily on transpiration. Animal production depends on the use of feed produced by transpiration, unless it has been imported, in which case the feed incorporates "virtual" water, reflecting transpiration occurring in another system boundary.

Because of the more needs of water to produce animal food than to water them, introducing management practices of animal herds that promote useful transpiration by consuming cropped fodder plants or residues or by infiltration of available water through longer soil cover will likely increase livestock water productivity. In fact, increasing livestock water productivity can be understood as:

- maximizing the number of livestock or the production of animal products and services using the same amount of water;
- producing the same benefits with fewer animals and less demand for agricultural water;
- adjusting animal production to the growing demand with same surfaces and water available;
- reducing herd size with same benefits and water use by increasing animal meat quality and quantity per head;

Three basic strategies are developed by IWMI to directly help to the increase in livestock water productivity: *improving feed sourcing, enhancing animal productivity* and *conserving water*. Improving feed sourcing leads to three important issues: *the water productivity of feeds and forages, conversion of feed to animal products and services, and the distribution of feed resources*. Water productivity of fodder is between 0.5 and 8 kg of dry aerial biomass per cubic meter, depending on the water available and species (with all their physiological factors) (IWMI 2007). Currently, research is being carried out to select more productive fodder grasses.

Crop residue and by-products are a unique opportunity for feed sourcing because this resource does not require any additional evapotranspiration. The use of crop residue can boost farm income without the use of more water. This technique is already used by farmers in the region that has been examined. Another required step is to grow more crops with residues that are better digestible and more nourishing for animals. Fodder quality and good feed balance determines animal healthy growth but defines also dung quantity and quality (fibres, minerals,…). Managing this resource conduct to close nutriment cycle for maintaining both soil structure and fertility. Therefore are fodder's choice, herd management and fertilisation strategy a set of key elements to optimize farm's production.

To enhance feed conversion to animal products and services, the digestibility of feed must be increased. It varies between 20% and 70%, whereby the undigested components are returning into the ecosystem in the form of manure (IWMI 2007). Manure production is, therefore, also consuming water; it is beneficial concerning nutrient replenishment, household fuel and home construction material. Potentially, genetics are able to improve this conversion but feed regime and herd management are also influential factors. Energy spent by the animals to access water and feed resources must also be reduced and used for meat and milk production.

Distribution of feed resources remains an important aspect and aims at enhancing livestock water productivity by balancing animal stocking rates with sustainable feed supplies. Mapping the regions concerning available feed resources and herd positions allows the development of strategies that enable choosing between supplying herds with water and hay or transporting them to other regions, organising the hay harvest and conservation, defining livestock pathways and planning movements.

The annual rainfall for the Northern region of Ethiopia is in excess of 1000 mm. As a result, applying water conservation techniques might not be desirable. This is discussed in more detail in chapter 5.3.4 on irrigation and water management.

3. Material and Methods

3.1 Study location

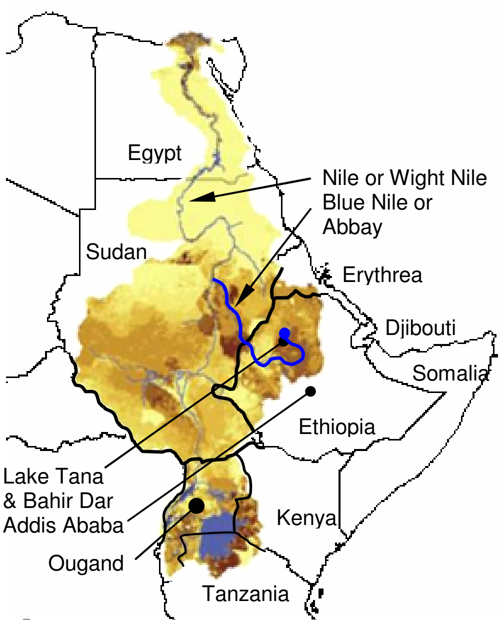


Fig.3: Nile basin (brown gradient is for livestock density) and related countries, East Africa.

The Nile basin covers the surface coloured in brown of Figure 3. The Abbay or Blue Nile Basin, with a catchment of 330'000 km^2 at the White Nile confluence in Sudan, has an average flow of 50 km^3 per year, constituting approximately 60% of the total Nile flow.

The Gumara watershed and the study region are shown in Figure 4. This basin is estimated to be a catchment of 2'400 km^2. The Gumara River runs from the Guna summit at 4'231m down to Lake Tana at 1'830m, covering a distance of approximatively 80 km to the East of Lake Tana. This watershed that is the object of the presented study is part of the bigger Amhara region that contains the entire Lake Tana watershed.

Projects that have already been completed to assess upstream-downstream relationships, together with current projects were one of the reasons for choosing this region (ILRI 2007).

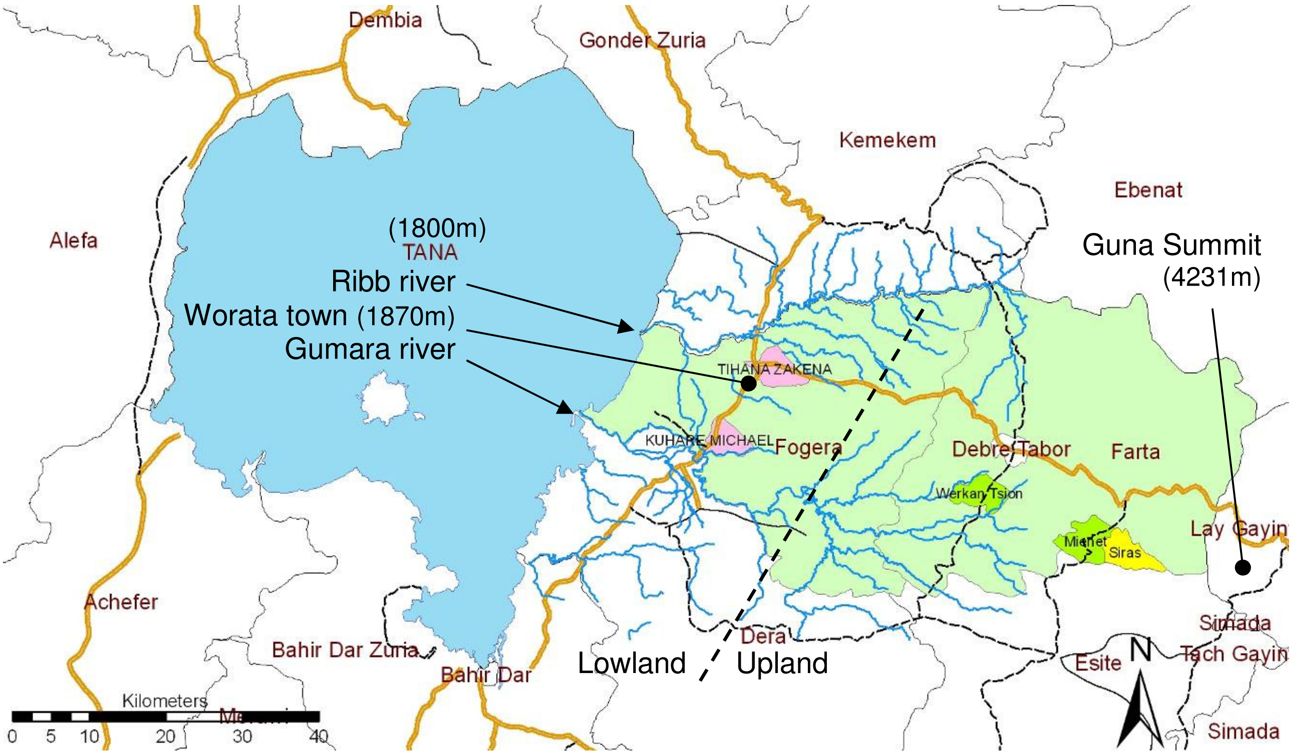


Fig.4: Study location. In light green the Fogara and Farta district, in rose the two Peasant Associations (PA) of Kuhar and Woreta (lowland); in green the two PA of Worken and Maynet (upland). (Spelling of PA might differ between maps). Areas East of dotted line are defined as upland and West of it are lowland.

3.2 Climate

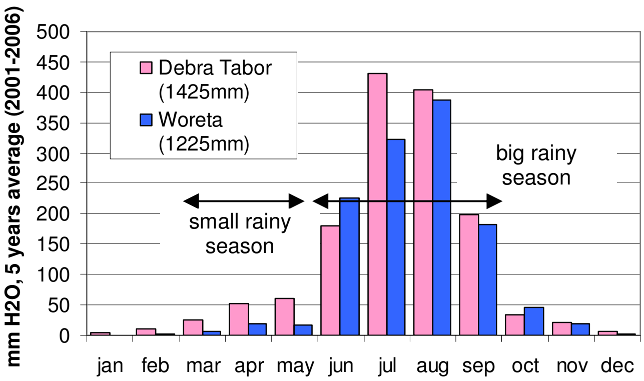


Fig.5: 5 years average rainfalls (2001-2006) in Debra Tabor and Woreta (Data adapted from National Meteorological Services Agency, Addis)

Figure 5 shows average monthly rainfalls during the past five years in Woreta and Debra Tabor. The graphic shows that this region has a pattern of one rainfall period divided in a small and a big period of precipitation, the small one lasting from Mars to May and the heavy rain from June to September. The latter is delivering uneven and heavy rains. Rain for the lowland region amounts to approx. 1225mm and for the upland to approx. 1425mm per annum. This year 2008, the minor rainy period failed, which causes the farmers some concern regarding the performance of their next yields.

The monthly average temperature is quite stable throughout the year, averaging 17℃ in Debra Tabor with a variation between 7℃ to 26℃; the hottest period is February to May. Woreta is approx. 3℃ warmer than upland, varying from 13℃ to 28℃. Frost occurs at 2800m and above (from informal interview in Soras).

The relief is quite uniform and progresses from the flat surface of the flooded areas in the lowland near the lake to a very steep slope (>40°) at 2400m. From the lake to the height of 3000m, the runoff from the rain deposits sediments on several tablelands. As soon as there is a slope of 5° or more, there is presence of impressive gullies which are mostly situated on free overgrazed areas at all altitudes (Photo 1). Above 3000m, the gullies remove the thinner arable soil layer, exposing the rounded surface of limestone rock (Photo 2 and 3).

Photo 2: Gully old formation in a free grazing area, south road from Debra Tabor to Bahir Dar, 5/17/2008.

Vertisol black or brown soil is dominant. It is a mix of silt and clay whereas the clay is present at a higher proportion. Due to the lack of sand, it sticks to other surfaces when wet and becomes very hard when dry once the moisture residues have evaporated. This results in surface cracks that make the surface unstable for construction. Organic matter enters these cracks and is mixed into the soil by the constant cycle of compression during wet weather and decompression during the dry season. As a result, this soil is quite fertile (black or brown colour) but allows more run-offs due to the high clay content. Water carries large amounts of silt, colouring rivers with dense reddish brown alluvion which indicates losses in fertility. Moreover, irrigation systems will clog.

A research project on the evolution of Lake Tana and its resources estimates that, at this rate of erosion, the lake will be completely filled within 12 years (Dr. Hespeler-Boultbee 2008, personal communication) . Annually, approx. 180 to 900 t/km^2/year of soil are drained in the rivers, thus contributing to the decline in fertility and downstream irrigation system pollution with silt deposit (Rodecco 2002 cited in Ayalneh 2004). The potential for irrigation is high, but mismanagement can easily lead to negative impacts like salinisation or conflicts.

All of the Ethiopian economy is highly determined by the success of agriculture, which in turn is also dependent on water supply through rainfall and irrigation techniques. The country is at risk of drought and chronic food shortage due to the highly variable rainfall, frequent floods and drought, and a lack of water storage facilities. Natural areas like forests, grazing reserves and steep lands are continuously annexed as cropping land, creating encroachment between farmers and herd keepers. This has set in motion a vicious cycle of declining wood supplies for fuel and an increase in using dung and crop residues as domestic energy instead of closing the nutrients cycle and replenishing soil fertility. Water productivity should be improved and efficient irrigation systems have to be put in place to counteract the decline in productivity in rainfed agriculture and to cover the need to double food production for the next two decades.

Photo 3: Soil surface losses due to slopes' erosion with rock appearance, Worken region, 3/23/2008.

3.3 Economics

Unique among African countries, the ancient Ethiopian monarchy maintained its freedom from colonial rule with the exception of the 1936-41 Italian occupation during World War II. In 1974, a military junta, the Derg, deposed Emperor Haile Selassie and established a socialist state. Torn by bloody coups, uprisings, wide-scale drought, and massive refugee problems, the regime was finally toppled in 1991 by a coalition of rebel forces, the Ethiopian People's Revolutionary Democratic Front (EPRDF). A constitution was adopted in 1994, and Ethiopia's first multiparty elections were held in 1995. A border war with Eritrea in the late 1990s ended with a peace treaty in December 2000, but today relations with Eritrea still remain sensitive.

Ethiopia's poverty-stricken economy is based on agriculture, accounting for almost half of GDP, 60% of exports, and 80% of total employment (CIA 2008). The agricultural sector suffers from frequent drought and poor cultivation practices. Coffee is critical to the Ethiopian economy with exports of some $350 million in 2006, but historically low prices have seen many farmers switching to qat[3] to supplement income. In November 2001, Ethiopia qualified for debt relief from the Highly Indebted Poor Countries (HIPC) initiative, and in December 2005 the IMF voted to write-off Ethiopia's debt to the body. Ethiopia suffered another drought late in 2002, leading to a 3.3% decline in GDP in 2003. Normal weather patterns helped agricultural and GDP growth recover during 2004-07.

[3] Locally pronounced *tchat*, it is an illicit but tolerated drug for local consumption coming from chewing the leaves of the bush *Catha edulis* that have stimulant and euphoric effect like amphetamines.

3.4 Farming systems and structural organisation

In this Gumara watershed, there are three typical farming systems. The production in the lowland (1800m – 2200m) is based on rice, maize, sugarcane, tomato, onion and peas, using the seasonal floods of the lake. The use of this flood for rice production and irrigation for onion or cereals allows harvesting two to three crops per year. Mixed livestock and some milk production are also present. Middle land reaches from 2200m to 3400m and produces less diversity: wheat, barley, potato and beans. The farmers have mixed livestock without milk to sell. In the highland, from 3400 to 3700m, only barley and potato can be produced during a long growing period. Sheep that grazes the highest places are the main livestock. Semi-transhumance exists from October to April (dry season) where cattle herds move from the highlands to the lowland plains and back. This kind of management is more frequent in the North of Lake Tana.

An amount of 500 to 2000 farmers are organised in a Peasant Association (PA) or Kebele, 20 to 50 PAs cover a region called Woreda or district. A group of Woredas define a region. The watershed is another boundary that is independent of Woredas. There is one Ministry of Agriculture per region. Subordinated Ministry of Agriculture Offices are responsible for the management of extension agents on the Woreda level and organise material flows like new seeds, fertilizers and chemicals. There are three extension agents per PA who provide information regarding good agricultural practises or promote governmental strategies. They are young people from the agricultural school and welcomed our study. Parallel to this education, farmers have technical support form NGOs like CARE and GTZ on soil conservation against erosion, gullies remediation, fodder improvement techniques, health centres and latrine installation.

Under Ethiopia's constitution, the state owns all land and provides long-term leases to the tenants; the system continues to hamper growth in the industrial sector as entrepreneurs are unable to use land as collateral for loans. Family successors divided land and several reallocations scattered plots to serve equitable repartition of fertile areas. This repeated process that takes place since the socialist government of 1974, together with growing demands for land, led to social tensions and lower interest to valuate land. It is strictly forbidden to sell land but farmers are allowed to exchange it.

3.5 Sample size

Altitude	Numbers	PA	Numbers	Farming systems
Lowland	15	Kuhar	8	mixed, dairy
		Woreta	7	1 crop only, mixed, dairy, milk sell
Middle land	14	Maynet	6	mixed, dairy
		Worken	8	mixed
Total	29			

Table 1: Resume of the sample size in the 4 PAs and their farming systems

To assess these agricultural production systems in accordance with other projects from ILRI and IWMI and due to the logistics available to go on site, 4 groups of 8 farmers were chosen: 2 in the middle altitude and 2 in the lowland as shown in Table 1. Access to the highland region was too difficult to carry out several surveys. The four coloured areas (pink and green) in Figure 4 show the four Peasant Associations chosen in the Farta district (Kuhar at 1850m and Worata Zuria at 1810m) and the Fogara district (Maynet at 2850m and Worken at 2380m). Figure 6 profiles each PA on the relief from Lake Tana to Guna summit. Farmers were chosen according to their accessibility by car, their interest on participating in the research, their ability to give answers, and, if possible, involvement in other IWMI and ILRI surveys.

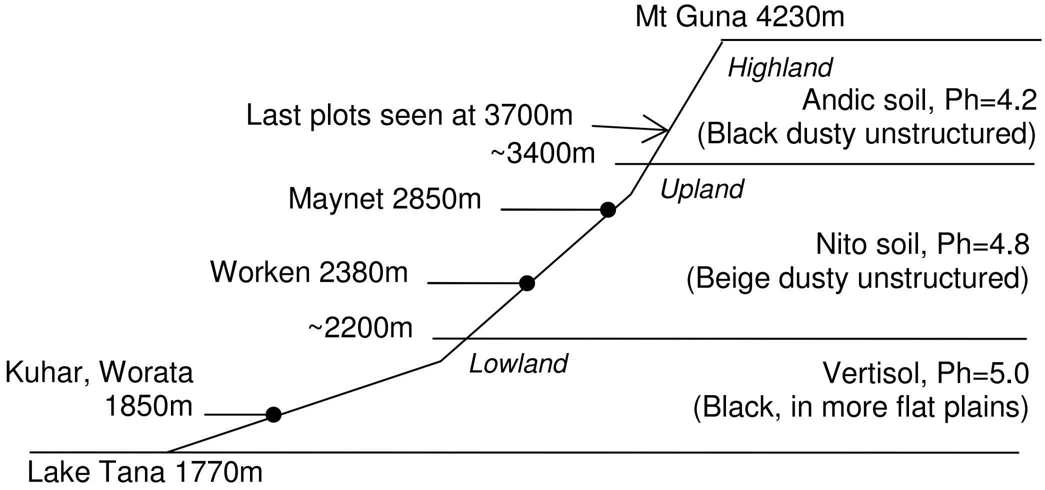


Fig.6: Profil of regions, selected Peasant Associations and types of soil from 1800m to 4230m in the Gumera watershed (altitude values from GPS)

3.6 Team and organisation

Starting on 9th of February 2008, Wagnew Ayalneh, scientific collaborator in ILRI for over 20 years introduced the student to the context and efficiently managed logistics for all field work carried out over a period of 61 days. The first step was to explain the RISE tool to Wagnew. The RISE questionnaire was then adapted and tested during a week involving 4 farmers from the low- and upland of the studied region. The questionnaire was adapted several times while experience was gained; all changes and their justification are listed in appendix 1 "Changes and Justifications".

On site, several enumerators already in touch with ILRI-IWMI teams were employed to help to select suitable farmers. These enumerators were already familiar with the PAs and were able to organise appointments with each farmers. Within a short time, two teams were organised: one lead by Wagnew and the driver Degefa Birru, and one containing the selected, most motivated young enumerator/ translator Jibrill Alemayehu and the student. The efficient setup freed some spare time that was spent for logistical purposes. Two periods of serial interviews were carried out, resulting in 31 original, fully answered questionnaires. At the start of the 2nd period, the two PA's of the upland were provided with each a feedback so that the student and farmers would already have an indication concerning possible ways of entry points. The time gained by carrying out the interviews in two teams was used at the end of the second period to expand on some aspects by organising informal interviews with different actors related to the field (see Acknowledgement).

The last week of field work (4th journey) was spent with the smart driver Aklilu Alemu, and was used to provide feedback to the two PA's of the lowland and NGOs like CARE (supported by USA, www.care.org, in Debra Tabor), GTZ (in Debra Tabor) and the Ahmara Regional Agricultural Research Institute (ARARI, West of Bahir Dar).

Data was always entered during the field work and data cleaning and its management was carried out in Addis, once the field work was completed during the remaining month prior to the final presentation to ILRI staff on June 23rd 2008.

3.7 RISE Tool

The RISE tool (Response Inducing Sustainability Evaluation) developed by the Swiss College of Agriculture (http://rise.shl.bfh.ch) is used to asses sustainability of the agricultural production. It summarises the farmer's management using 12 indicators. It basically consists of completing a standard questionnaire during a four hours interview with the farmer, entering data into a the RISE program and printing of the output document showing the 12 indicators in a spider diagram and in numbers. The results are then analysed more in-depth and compared with the context in order to pinpoint possible improvements. These are then discussed with the farmer in feedback meetings.

The tool allows the assessment of one farm at a time and does not yet cross easely data for analysing groups. Despite this, several interviews in a particular region, together with the lecture of indicators after data processing, can enable projection of a regional average of sustainability. The tool can be used at different time intervals to analyse a trend, the impact of a policy or to analyse the impact of an implemented project, for example. Moreover, it is also possible to use the results together with context expertise to stress entry points and to define new policies or, at least, to serve for consultancy purposes. The RISE tool is not simulating the farming system, it reads it. It can not be used to find the cause of the problem, but will list factors or typical methods contributing to more or less sustainability.

An indicator is the result of the state parameter from which the driving force parameter is subtracted and indicates the degree of sustainability. In instances where the driving force is higher than the state parameter, the sustainability value or final indicator will be negative. State- and driving force parameters are composed of several other parameters connected to farmer's answers through formulas, tables and scales. Parameters are scaled from 0 to 100 and their addition allows to setr the final sustainability degree from -100 to 100.

The RISE team prepared an additional tool to allow assessing the financial situation of farmers without bookkeeping. Normally, the accounting system provides RISE data on finance. In this case, the finance data stems from Excel files containing data collected during the interviews.

Due to the different context of modern farms[4] and farms in Ethiopia, the questionnaire was adapted and some scales were redefined. The document "Change and Justifications" attached in the Appendix relates all the work carried out to adjust the questionnaire to the conditions of Ethiopian farmers. Moreover, the questionnaire had to be adopted in such a way that the interviewees would not become to bored to carry out this long interview. A week was used to test and validate the improved questionnaire and feedback method using two farmers in the upland and two in the lowland.

Out of the initial 32 farmers to be interviewed, two were incomplete and one missed the appointment. 29 valuable questionnaires were finally used for further analysis. Feedback was carried out per group and not per individual farmer due to the high homogeneity of the results and lack of time. Moreover, there was no guarantee that the farmer would keep the appointment. The four feedback meetings turned into a kind of extension course based on RISE results with lively interaction involving all participants - including extension agents and even the PA chair.

[4] "modern farm" is considered in this text by the author as a farm which RISE original questionnaire can be applied as it is, without adapting the questions, so that the farmer can fully understand the questions fitting the context. See also appendix on Changes and Justifications.

3.8 RISE and farming system boundaries

The sustainability of the *farming system* would englobe agricultural activities, the household works, the production of the intrant, the agro-transformation after production and other remunerative works. The boundary of the RISE tool, however, is defined at farm level and RISE analyses only the *agricultural activities*. Household activieties have the most importance in our study area after the agricultural activities. The effect of the family consumption on the sustainability of the entire system has a greater impact on agricultural sustainability for a poor farm than for a modern one, because of the family size compared to the farm dimension. Therefore and to keep the right overview of the all *farming system* and what is global sustainability there, questions were added to also collect data concerning this aspect and thus to complete the RISE *agricultural production* assessment.

Plots that are rented in and out are also included in this analysis because they were easy to record[5]. Free grazing areas were not taken into account as part of the agricultural production due to the difficulty of obtaining information concerning the overall management (surface, number of heads, time of grazing,…); this would be an ideal subject of an additional study. Additional links are analysed and entry points developed due to the severe problems caused by erosion and fodder productivity of these surfaces. These certainly affect farm sustainability.

In order to expand the boundary from agricultural production to the all farming system and to have a deeper look at the water situation and general farming management original questionnaire was updated with additional questions such as:

- Increase in different seasonal periods (rain, irrigation, fodder shortage)
- Increase in types of surfaces recorded (rented , let, irrigated)
- Animal diseases and vaccination
- General amount of water used (mostly for home consumption and local beer production)
- Distance to water bodies
- Distance of plots
- The use of crops residues (eaten by his/other animals, buried, burned)
- Crop diversification
- Home consumption (food, divers, energy) (in quantity and monetary using market prices surveys)
- All family members (age, gender, work force or not)
- Farmers opinion on farming difficulties and their future projects (sociological data)

In addition, prices were recorded at the market place nearest to the interviewed farmers[6].

3.9 Data Management and Analysis

A RISE interview produces 200 standard answers per farmer at least. For a farmer with 7 plots, 10 crops and a workforce of 5, an interview collects 615 answers. This data is then entered into the computer program and processed, producing an output Excel file of 114 parameters without unit (-100 to 100) that is then converted to present the final graph containing 12 indicators. The Output Excel file of RISE and the Financial Tool were enhanced to present over 140 additional calculated numbers that describe the farming system using units. Answers entered from questionnaires (raw data) cannot easely be exported from the RISE program. As a result, some

[5] See Appendix 1 "Changes and Justifications, Chapter Land Types and RISE Boundary" for further explanation on its signification in the RISE calculation.

[6] Markets' prices list can be found in each Excel files "Financial_Tool", sheet "Ceremony_..." on the CD-ROM

of these rough data had to be entered a second time into Excel files due to the need of processing data in another way.

Figure 7 shows the details of process data collection together with their origin. From the 29 questionnaires, the Financial Tool files and Outputs produced, one new Excel file has been created (raw Data) to gather state parameters, driving force parameters, other calculated numbers and selected data from the questionnaire and Financial Tool (manually entered, not exported by RISE). The Output file has been linked to the Financial Tool files to allow direct correction so that data from the RISE program could be reprocessed if necessary. A new sheet has been created in the Output Excel Files (Resum4Export) to collect in a single row all data from the file in a clear manner for export for analysis, using the copy-paste[7] method.

Additional Excel files have been created to enter data from questionnaires to facilitate in-depth study and description of specific topics like herd size and composition, market prices evolution, finance, sociological data etc. Yields have not been re-entered for further analysis due to lack of time and the uncertainty of data (see Chapter 4.2.2). Copies of the RawData file were made and modified for in-depth research using sorting function, graphs and columns using different formula to detect, describe or stress the situation per topic. SSC-Stat 2 is an Excel plug-in tool that enables the presentation of data in a box-plot style (present on the attached CD-ROM). SPSS was only used to confirm some suspicious correlations.

[7] Use "Paste Special…" function and choose "Values and number formats" option to avoid creation of a link between Excel files.

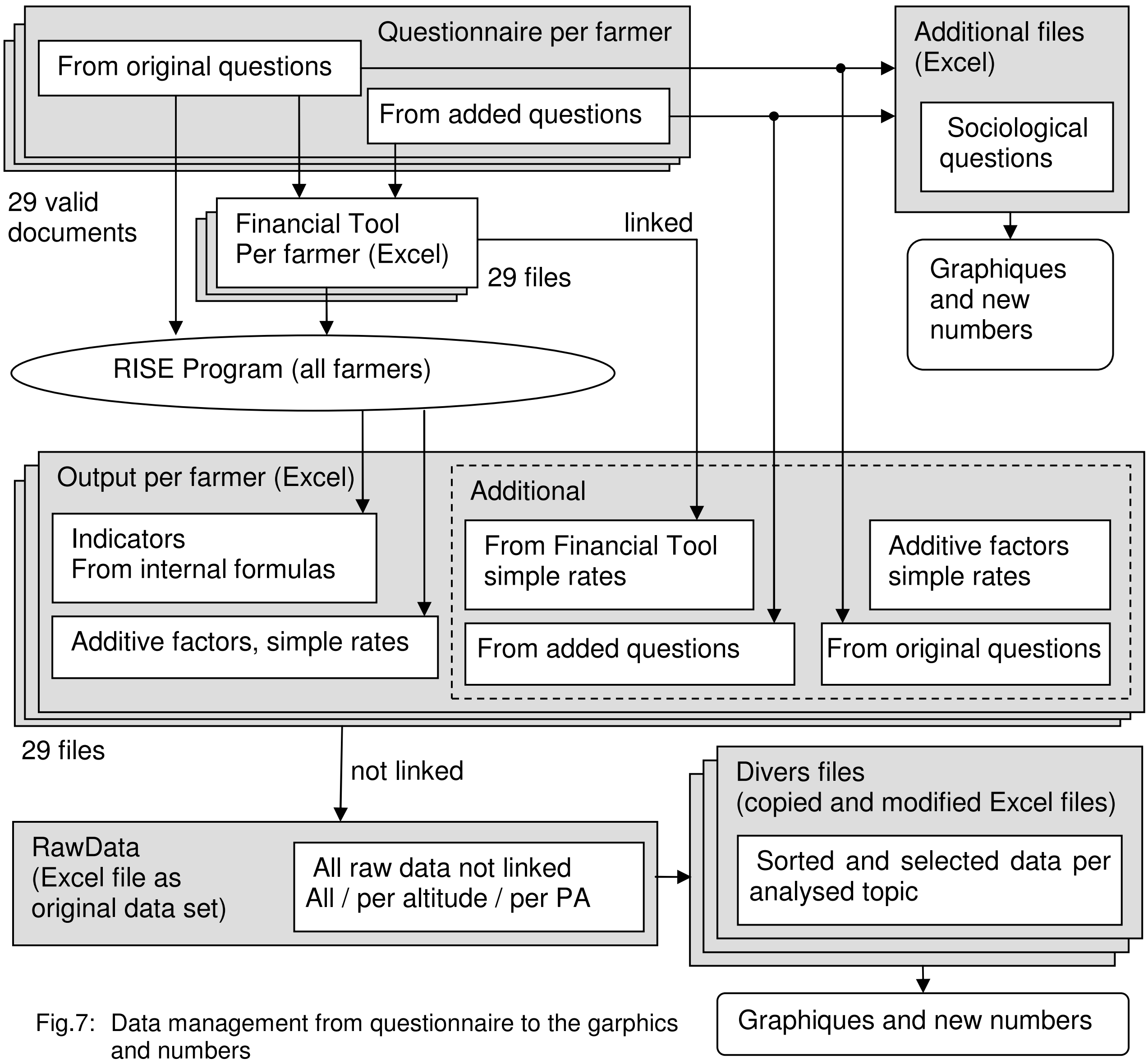


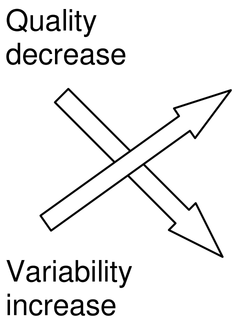
Fig.7: Data management from questionnaire to the garphics and numbers

4. Sustainability of agricultural practices – Results and recommendations

This section presents the RISE results in more details and discusses each of the parameters. The following discussions enable the introduction of founded recommendations. These recommendations are at farm level and do not take into account overall economics or the social scene. The entry points proposed in chapter 5 will cover all of these recommendations using intermediate entry points that focus on practical techniques that should be implemented.

4.1 Sources of variability

Non of the farmers keep a written documentation. As a result, the data are communicated verbally and are susceptible to being incorrectly remembered or influenced by psychological parameters. The above, together with other factors that are shown in Figure 8, decreases the precision of the results and increases their variability.



Reasons and sources	Programmer	Inter-viewer	Farmer	Pro-cessor
Complicated questions	X			
No written data			X	
Lies, wrong estimation, no knowledge			X	
Time-span and boredom	X	X		
Missed question from interviewer		X		
Missed or wrongly recorded answer		X		
Misunderstood question		X	X	
Bad mood, disturbing environment		X	X	
Wrong intermediate calculation	X			X
Answers not matching RISE options	X	X		
No adequate standard data				X
Misunderstood answers				X
Mistakes by entering/cleaning data				X

Fig.8: Reasons of data quality decrease and variability increase

The amount of time required to complete an interview was 3.5 to 4.0 hours. The interviews were carried out in a single session at the farmers' request. The interviewees were bored towards the end of the interview and when required to list product flows, home consumption and fixed assets; the farmers often omitted some information or were quick at putting numbers to a question. The interviewer was also too tired to pay continuous attention to the work. These factors decreased the richness and precision of the data. No solution was found for this specific problem, despite strong efforts to reduce the data quality decrease (adaptation of questionnaire, good preliminary explanations, data control and cleaning). The following paragraphs detail some aspects of these variations and their impact on the results.

4.1.1 Livestock data

Despite intensive investigations data on livestock nitrogen and phosphorous production through dung could not be established[8] due to lack of time available. Other data of the same category, stemming from the RISE model, were used instead. These data are used for computing soil nutrient depletion (SO_DP4) in the N&P balance (NP_SP1 and NP_DP1) and in the cropping system description (PS_DP1) of the crop protection indicator. The RISE figures stem from modern countries where the animals consume and produce nearly 50% more than tropical livestock. This bias increases the amount of livestock nutrient production. The measured unbalance, however, that indicates low yields and large amounts of nutrient losses, remains unaffected.

4.1.2 Yields

Calculation of the self sufficiency rate, together with large differences compared to national reachable average yields demonstrated that the records on yields provided by the farmers are unrealistic (Waterfootprint 2008). This is due to misunderstandings regarding the kind of units used (per plot or ha), bad yields, land surface**,** amounts of yields sold and stock estimations. Wrongly remembered information from the farmers and insufficient attention to detail by the interviewers who did not detect obvious errors during the interview were other contributory factors. This again increases the variability of the related indicators. As a result, no in-depth study of yields and their influencing factors was carried out.

4.1.3 Minimum and average regional wages

The RISE economic and social indicators are using minimum and average regional wages to estimate the impact on the region in terms of farm economic attractiveness. These wages affect indicators like, e.g. the share of regional work force and salaries (LE_SP1), lowest farm salaries compared to regional average wages (LE_SP2), disparity of incomes (WC_DP4), working time required for reaching the minimum wage (WC_DP5) and means of subsistence (SS_SP2). Different sources showed a broad variation in defining these regional wages. Less funds are required for survival in rural than in urban areas. In contrast to the urban economy that is based on liquid assets, rural areas are based on assets required for self sufficiency, the ability to work, exchange in nature and services, like labour sharing for example. The current rapid increase in inflation rate (doubled between May 2007 and May 2008, wheat price) shows regional differences that made the task more difficult.

[8] This reference in an ILRI publication was only detected on the Internet during the final stages of writing the paper: Estimation of animal manure production, Asrat, M., Gideyelew, T., Peden , D., Taddesse, G. & Haileselassie, 2006.

Values in Birr	Monthly	Yearly
Minimal wage in Ethiopia	350.-	4'200.-
Average wage in Ethiopia	800.-	9'600.-
Minimal wage for survival in Bahir Dar		2'400.-
Engineer's salary in Bahir Dar	1'100.-	13'200.-
ONG typical salary	3'000.-	36'000.-
Prime Minister Other Ministers	14'000.- 4'000.-	
Fulfilled RISE list of living costs for Addis Abeba		27'600.-
Fulfilled RISE list of living costs for Woreta		19'800.-

Table 2: Different minimum and average wages stemming from informal interviews carried out February to May 2008.

To avoid this regional- and social class variation of living costs, a trial was carried out using farmers in RISE entered data. The average of the lowest salaries per farm were taken as a minimum regional salary and the overall average of the farmers data as average regional wage. This creates a comparison at regional scale of units for an identical working class (farmers) and ignores other professions or urban working environments. This is, however, not advisable as it makes it impossible to take into account context impacts such as migration and farm work attractiveness. The variation seen in Table 2, does not justify the choice of these two key numbers, where results can easily be amended. This is a situation that RISE should keep under tighter control.

The final calculation is carried out using 19'800.- as an average wage that is required to have an acceptable living standard in Woreta. The percentage from the difference of the first 2 numbers in Table 2 is used (43.75%) to define the minimal regional wage of 8'662.-. Wages are calculated based on the estimated salary that would be paid for the same work without household expenses which can be considered as doubling the wage value.

4.2 Sample overview

The study sample consists of farmers living at 2 different altitudes that are farming crop and livestock. Some are able to produce milk for home consumption. The sample in Woreta, situated in the lowland, was chosen due to their ownership of cross-bred cows that enables the sale of milk to a local cooperative. Table 3 presents this sample in more details. Farmers aged from 30 to 70 (average 35 years) having an area of farm land ranging between 0.86 to 5.26 ha (average of 1.9 ha) were interviewed. They possess between 4 to 14 plots each (average of 9.1) and 45% of them irrigation average 14% of their plots.

One farmer does not possess animals and hires drought power from family members. The other farmers possess between 1.0 and 16.8 TLU (average of 4.7 TLU) composed of cattle, sheep, goats and chicken. Guard dogs are not included. In instances where the cows produce milk for home consumption, the quantity averages 420 litres per lactation whereas the cross bred cows (Holstein – Zebu) produce an average of 2'115 litres per lactation for their owners. 48% of the farmers do not milk their cows.

Farmer	PA.	Farm type	Age	Work forces	Agricultural land	Irrigated area	Number of plots	Tropical Livestock Unit	Produced milk per year	Operating income	Calc. net profit/loss
					ha	%		TLU	litres	ETB	ETB
F05	Ma	mixed, milk	38	1.09	1.930	11	14	3.1	360	9'041	-24'394
F06	Ma	mixed, milk	30	0.55	2.495	0	9	3.2	540	13'177	-8'957
F07	Ma	mixed, milk	45	0.52	1.200	0	9	4.2	540	848	-20'992
F08	Ma	mixed	35	0.35	1.260	0	5	2.6	0	7'456	-5'143
F09	Ma	mixed, milk	57	0.68	0.860	15	5	3.8	180	30'329	6'690
F10	Ma	mixed, milk	52	0.73	1.350	4	10	4.8	420	15'473	-9'496
F11	Wk	mixed	36	0.40	1.300	19	9	3.8	0	7'871	-13'468
F12	Wk	mixed	70	0.83	1.270	0	8	5.5	0	276	-27'148
F13	Wk	mixed	42	0.66	1.690	4	9	3.4	0	13'761	-11'763
F14	Wk	mixed	35	0.35	0.950	6	7	3.0	0	7'407	-12'748
F15	Wk	mixed	45	0.49	1.285	2	10	3.0	0	6'013	-13'709
F16	Wk	mixed	54	0.90	2.240	0	10	4.8	0	13'201	-21'229
F17	Wk	mixed		0.55	1.950	0	11	3.4	0	7'347	-16'679
F18	Wk	mixed	61	0.57	0.765	0	9	3.2	0	874	-21'620
F19	Wr	mixed	54	0.45	1.450	30	6	1.0	0	5'079	-14'874
F21	Wr	mixed, milk	37	0.66	1.645	8	11	7.0	270	7'632	-27'048
F23	Wr	crop only	50	0.62	2.405	10	10	0.1	0	12'850	-17'380
F26	Wr	mixed, milk sell	38	0.59	0.830	0	4	2.7	2'460	39'764	12'341
F27	Wr	mixed, milk sell	61	0.80	2.500	0	7	6.5	2'160	4'856	-27'714
F28	Wr	mixed, milk sell	52	0.81	1.915	65	12	4.7	1'080	6'122	-24'955
F29	Wr	mixed, milk sell	38	1.49	4.565	0	14	16.8	1'890	7'776	-50'513
F30	Wr	mixed, milk sell	48	0.90	5.260	5	11	8.9	3'360	15'414	-18'239
F31	Wr	mixed, milk sell	38	0.71	1.620	0	7	6.1	1'740	16'677	-7'633
F03	Ku	mixed, milk	61	2.18	3.050	8	11	3.8	750	15'093	-50'541
F04	Ku	mixed, milk	35	1.40	1.530	0	8	4.0	540	4'029	-65'784
F20	Ku	mixed	43	1.74	1.105	9	9	3.2	0	5'712	-62'207
F22	Ku	mixed	30	0.28	1.500	0	6	2.1	0	6'561	-23'147
F24	Ku	mixed, milk	45	0.57	2.430	2	9	3.1	180	5'712	-20'024
F25	Ku	mixed	48	0.90	2.612	27	14	8.4	0	8'124	-27'619

Table 3: Set of characteristic of the selected farmers.
PA: Peasant Association: Ma = Maynet; Wk = Worken; Wr = Woreta; Ku = Kuhar.
Maynet and Worken are in middle altitude, Woreta and Kuhar in lowland.
ETB = Ethiopian Birr or national currency (1$=9.56Birr, 15.06.2008, www.xe.com)

4.3 RISE graphic on results

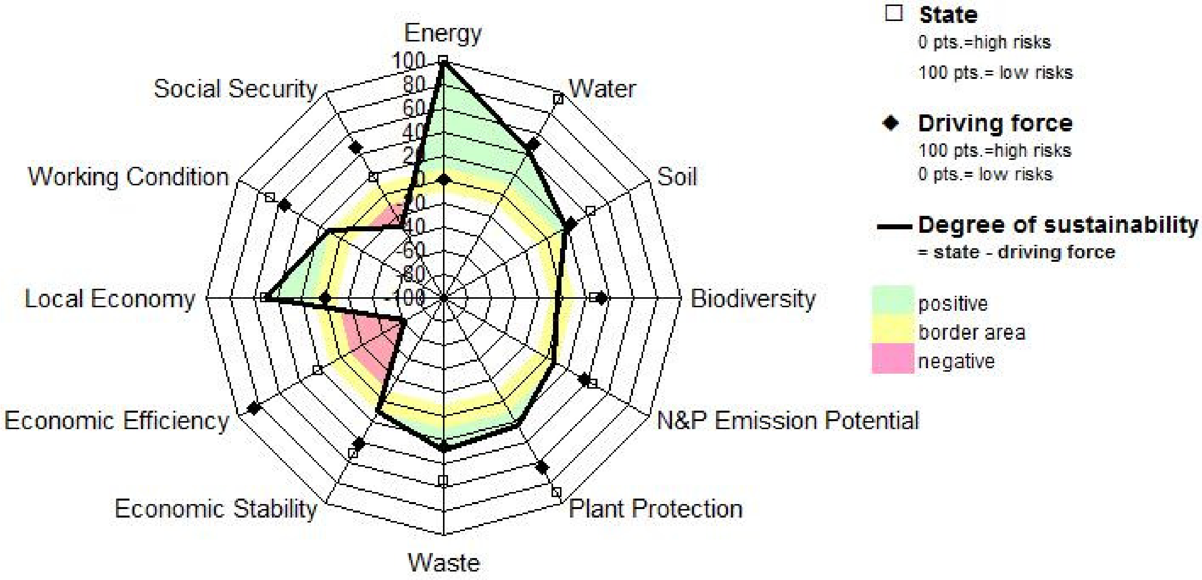


Fig.9: RISE sustainability graphic of all 29 farmers

Figure 9 shows the graphic of the average all farmers. Areas coloured in green show a good positions concerning the related indicator while red areas represent deficit in sustainability. Each indicator is explained in detail in the following chapters. Economic Efficiency obtains the worst results, only 4 farmers show a good position of economic efficiency and 1 farmer has negative sustainability for water.

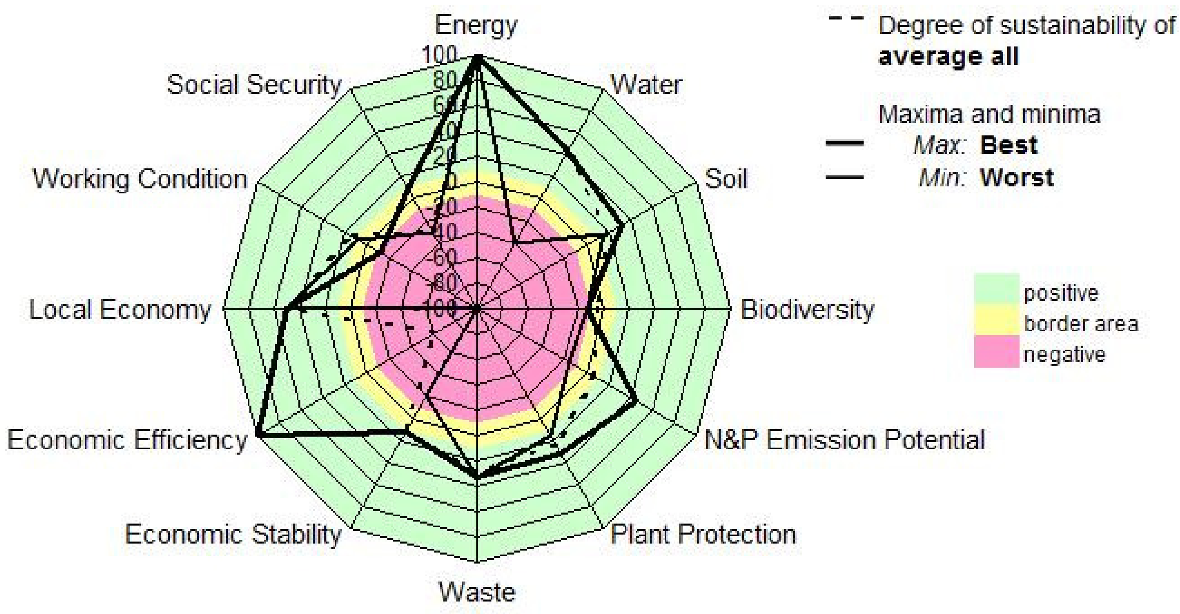


Fig.10: Best (outside line, F06) and worst (inside line, F21) average indicator showing where are variations.

An average of the 12 indicators per farmer has been calculated to classify the farmers and put into evidence the best and worst cases that are shown in Figure 10. The relevant differences between the farmers are their economic efficiency, N&P emission potential and social security. Water indicator difference is due to an exceptional situation explained in the related chapter.

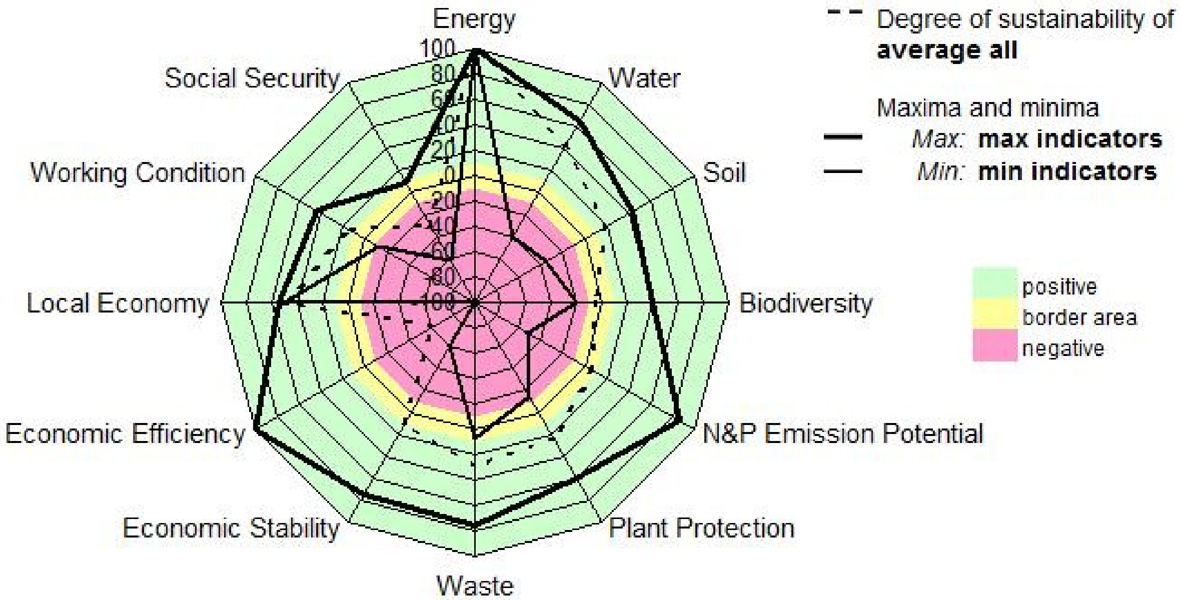


Fig.11: Best (outside line) and worst (inside line) indicators found by the farmers showing potential of development without intervention

Figure 11 shows the best and worst indicators found by the RISE analysis. The outside line represents the potentially best position which could be reached without interventions, if the context would be the best of all. Because RISE does not simulate farming systems but indicates the prevailing situation concerning sustainability, RISE is unable to evaluate if the actual context allows reaching the position of these indicators. The largest variations are apparent concerning economic efficiency, economic stability, N&P potential emission and social security. The sustainability of water management seems to vary; it is, however, influenced by only one negative entry, while there are three negative entries present for the soil indicator. Energy and local economy have fixed positions for all interviewees. The reasons are explained in related chapters.

Further graphs will show the indicators in more detail, using the "boxplot graphic" of SSC-Stat2, an Excel plug-in contained in the attached CD-ROM.

4.4 Energy

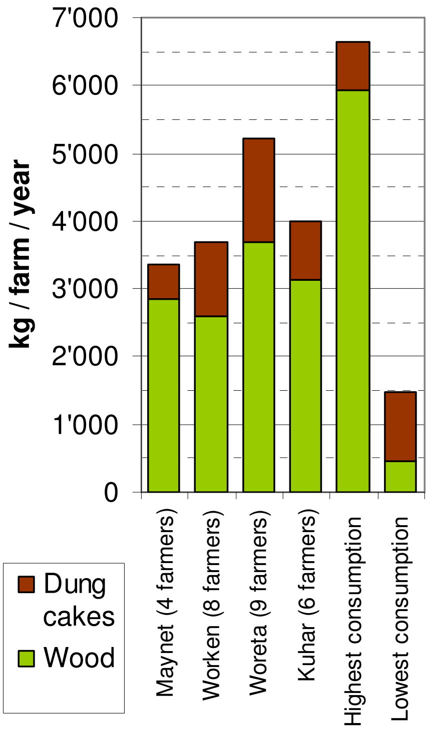


Fig.12: Per PA average wood and dung cakes home consumption per farm and

The Energy indicator looks at the different energy carriers used for agricultural purposes. It evaluates energy inputs per ha and per work force. Because farmers do not consume or burn energy for agricultural purposes, the indicator shows the best position at 100.

Household energy consumption was recorded in amounts of Eucalyptus wood, dung cakes and charcoal consumed with their local market prices. Quantities were entered in RISE as nutrient exports, values that influence the indicator on potential nitrogen and phosphorus emission and soil nutrient depletion. Their costs were included in the household overall consumption affecting the salaries for the local economy indicator.

The origin of these fuels, i.e. bought or farm produced, was not included in the questionnaire. Dung cake mainly stems from the farmer's herd and from collecting on common grazing areas. Farmers often grow Eucalyptus hedges for their own energy consumption and construction needs, but sometimes buy it on the market. Charcoal is rarely used by farmers, more by town inhabitants

, and is thus ignored from Figures 12 and 13. Figure 12 shows the proportion of wood and dung cakes for fuel consumption for households. The Woreta PA has the highest consumption per working person; however the lowest consumption is also found in this PA, showing a potential to lower overall consumption. In the upland consumption amounts to 3'500 kg per working person, this is slightly less than that of the lowland with 4'604 kg per working force.

One farmer (F13) produces charcoal, whereas at least three (F12, F13, F14) sell wooden poles. Looking at the nutrients' balance at a regional scale, burning any organic matter is a loss form the nutrient cycle at farm and regional level. Their inclusion in the farm boundary, therefore, affects the N&P indicator. This aspect is open to discussion with the farmer.

One interviewed farmer, situated in the lowland, irrigates its rice and onion plots with a motor pump; a few possess manual water pumps. There are, however no records concerning energy amounts, which is a pity as it represents a unique case.

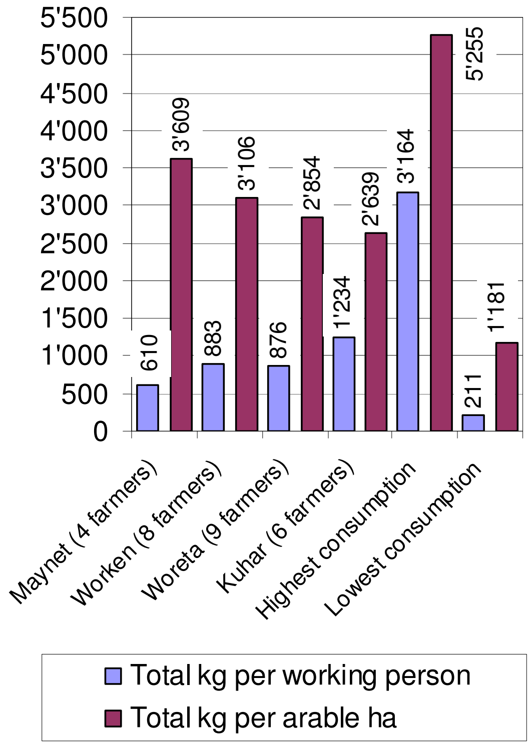


Fig.13: Total yearly energy consumption (wood and dung cakes) in kg per working person and per arable surface.

Figure 13 presents the total energy consumption in kg per working person and per arable land. In the lowland, there is less energy consumption per ha while the upland consumes less per working person. The lowest consumption shows the potential that could be reached (211 kg/working person and 1'181 kg per arable ha). Significant correlations are exposed in Table 4 and show that wood consumption increases with increase in surface. This is probably due to a similar rate of trees per surface for each farm. A correlation between the number of working persons and surface area is apparent. This not only indicates the amount of work to be done per surface area but also the number of working persons (wp) that a given surface is able to sustain (lowest 0.63 wp/ha; highest 3.02 wp/ha; lowland 1.75 wp/ha; upland 1.20 wp/ha)

R^2	Wood and dung consumption	Wood consumption	Working person
Arable surface	40%*	52%**	50%**
Farm total surface	Insignificant	39%*	58%**

Table 4: Relevant correlation coefficients between wood and dung consumption, only wood consumption, working persons, arable and total farm surfaces.
** Significant at 0.01 level; * significant at a 0.05 level

It would also be possible to carry out data calculations in relation to the economy to stress the monetary impact of this consumption.

4.4.1 Energy dilemma

The price of wood is increasing due to the growing city demand for construction material and energy. This pressure on local energy resources is increased by the rising petrol price and squandering due to increasing amount of vehicles with inefficient combustion engines. Charcoal is mostly made from Eucalyptus roots or is imported. The price, however, is for farmers unaffordable. Therefore, all farmers have some Eucalyptus trees as assets near their homestead. Eucalyptus has a good growing rate, stands straight and has a regular trunk without branches till the upper part. As a result, it is perfect as a construction material (form) and energy supplier (growth rate), has some bio diversification value and helps against erosion, but its drawback is soil life depletion due to the release of toxins.

In order to ensure energy supplies, the farmer mainly must choose between trees, dried dung and wood that is unsuitable for construction purposes. Trees are medium term investment, whereas dung cake is a resource that is faster available. Replacing a tree is much more work than harvesting dung. Dung composting technique belongs to long term strategies for increasing crop productivity, while burning dry dung satisfies different short term needs. A farmer must take into consideration these main facts, amongst possible other influential factors when faced with the choice on how to manage resources to satisfy the present needs and prepare for the future. It is, however, certain, that there is an obvious causal relationship between city growth that requires an increase in energy supply from the farmer and soil degradation.

4.4.2 Recommendations

1. Planting of Eucalyptus around the plots, as fence and for terrace stabilisation, along pathways, on slopes etc.
2. Limitation of wood consumption by using other heating techniques, like hotbeds, e.g., that decrease heat loss and oxygen needs, and, as a result, decrease wood consumption for the same temperature produced.

3. Increasing the farmers' awareness concerning the fertilization value of dung cakes to positively influence the mindset.
4. Increase in wood price, development of new energy resources for towns.

4.5 Water

On the one hand the water indicator displays a number of risks to the water supply in respect to the quantity and the quality of water used, on the other hand the efficiency of the water used in a global context is being scaled.

During droughts, when it is difficult to access sufficient good quality water, farmer's wives walk further and wait longer to bring home the water. From a farmer's view-point, therefore, water quality and quantity are good, as long as enough water reaches the household. The type of water bodies are only recorded in terms of renewable or not renewable (types of wells). The RISE questionnaire was improved to include more details and looks at seasonality, water quantity and quality for animal, crop (irrigation) and processing purposes but does not include domestic use. Additional questions in the standard questionnaire, however, included human drinking water consumption and the manufacturing of Talla (local beer).

Water availability differs between low- and upland. The five yearly average annual precipitation amounts to 1225 mm/y in the lowland and 1425 mm/y in the upland, both falling during 142 and 155 days respectively between June and September (Figure 5, see Chapter 3.2). Lowland farmers benefit from an average of 206 days of vegetation period, whereas the upland has a 246 day period. The lower precipitation amount of the lowland is offset by more water from broader rivers for irrigation purposes and from the Lake Tana floods. This flood affects farmers' plots at lake altitude (from 1800m to 1820m) between July and September and is used for rice production. RISE is currently unable to record such an irrigation situation.

4.5.1 Results

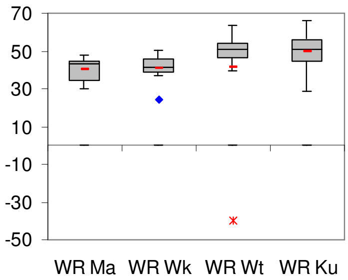
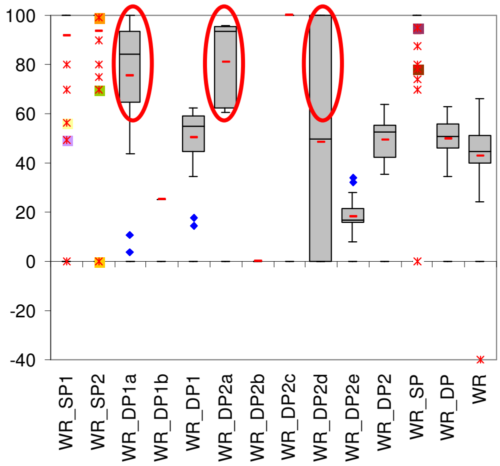


Fig.14: Water indicator from the 4 PAs (Ma= Maynet; Wk= Worken; Wt= Woreta; Ku= Kuhar)

Figure 14 shows that the average water indicator is quite high (~48/100), which is surprising. The water indicator (WR) of the Upland (Maynet and Worken, shown on the left) shows slightly lower values than the lowland (Woreta and Kuhar, shown on the right). The difference between the two altitudes is not evident in the water productivity for the crops (WR_DP1a, Figure 15). 42% of the farmers in the upland use irrigation, with an average consumption of 935 m^3 of water, whereas only 33% in the lowland irrigate their fields, using an average of 46'450 m^3 per farm.

For all for groups, the indicator on water contamination by manure (WR_DP2a) shows a general problem of water pollution by cattle entering the water bodies, reducing water quality and thus increasing downstream health hazard for animals and humans. There are no facility storing manure, dung piles and compost without leakage. This is a component of indicator WR_DP2a. These leakages increase the loss in nutrients, influencing the nutrients cycle of the N&P indicator. These losses cannot be easily quantified (not quantified by RISE).



SP= State Parameter (high values are good); DP= Driving Parameter (High values are bad); dash are means and dots are outsiders; circles show bad position of the indicator.

WR	Water indicator
WR_SP	Water (State parameter)
WR_SP1	Water quantity and availability
WR_SP2	Water quality and stability of the quality
WR_DP	Water (Driving parameter)
WR_DP1	Water quantity and productivity
WR_DP1a	Water usage and productivity for plant production
WR_DP1b	Water usage for animal husbandry
WR_DP2	Risk factors for the water quality
WR_DP2a	Water pollution by manure
WR_DP2b	Water pollution by silage leakage
WR_DP2c	Waste water production and treatment/disposal
WR_DP2d	Water protection by soil conservation/cultivation
WR_DP2e	Soil permeability (nutrients/pollutants)

Fig.15: Water parameters of all PAs

The interviewed farmers do not use silage as a means of fodder[9] storage. As a result, the indicator WR_DP2b is at zero. There is also no use of water for animal care or any agricultural processing, a situation that put the driving force on production of wastewater, its treatment and disposal (SO_DP2c) at 100, which affects the final indicator. Milk production can create some wastewater. This amount should not be recorded for home consumption (household out of RISE boundary) but for the milk producer that sells it (for of the eight farmers of Woreta). Its inclusion in the records was omitted.

Some of the farmers plough more frequently than others. This is shown by the driving force DP2d on Water protection by soil conservation/cultivation, a driving force which is too high for some of the interviewees. No significant differences are found between PAs and it tells that it is not related to altitude or PAs' habits.

4.5.2 Discussion

The relative high position of this indicator is mainly due to the positive point of view of the farmers on the quantity and availability (WR SP1) of water and on its quality (WR SP2). This fixes the state parameter (SP) at a high position, while bad driving forces (WR DP1a, DP2a, DP2d) cannot reverse this significantly. Another reason is that no water is used for animal care as in modern farm systems, no slurry dilution, no processing and cleaning of equipment, which limits the risk of doing wrong from the RISE model's view-point.

4.5.3 Water and health

The positive point of view on water quantity and quality of the interviewed farmers, is biasing the real state of these resources. On several occasions, it was observed that cattle were entering the same water body to drink as the one used by children and women to fetch domestic water. Of course the use of these waters depends on how far their body supports the bacterial pressure and toxicity from the fetched water. Table 5 shows that, during the past year, 80% of the farmers in the lowland have vaccinated some of their animals, compared with 50% in the upland. Even

[9] IPMS (Improving Productivity and Market Success of the Ethiopian Farmers) project from ILRI delivers in the region innovative techniques to a few motivated farmers like for example making silage of straw added with urea to feed mainly cross-breed cows (www.ipms-ethiopia.org).

with this precaution, the lowland has more livestock losses due to diseases than the upland. Farmers in the lowland perceive the diseases that affect their subsistence in the following order of importance: first and foremost crop, followed by livestock and finally humans. For farmers in the upland, diseases affecting humans would appear to be more important and livestock seems to play a subordinate role.

	Water pollution by manure (WR DP2a)	Farmers which vaccinated their animals	* Animal losses due to disease	** Frequency of the constraint on		
				Crop disease	Livestock disease	Human disease
Upland	82,5	50%	3,0%	19,2% (1)	7,7% (3)	15,4% (2)
Lowland	79,7	80%	8,9%	32,3% (1)	19,4% (2)	6,5% (3)

Table 5: Comparison of some health factors between low and upland
* Percentage of heads of all animals recorded without poultry
** From social questions on farmers' constraints (in brackets is the rank)

Figure 16 shows the nature of accessible water bodies. Woreta town is growing fast and some farmers had to move out of town, others stay and earn their main income from other activities (not included in the sample), others did not move or change activities and are now embedded in town, making a good living with cross breed cows and milk production (F26). The farmer located in the town has accesses to tap water for his animals (make the 7% in figure 16).

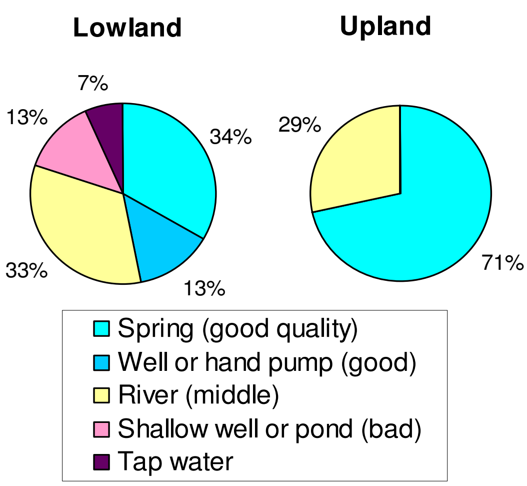


Fig.16: Water access types at the 2 altitudes

The diversity of water bodies in the lowland is higher than that at medium altitude. In the opinion of the farmers, water quantity never was a problem. Regarding health, two elements could explain the different ranks of farmers' worries regarding diseases. Firstly, spring water always is of good quality, whereas the quality of the river water decreases between up- and downstream. Secondly, people situated in the lowland have easier access to soil filtered water from wells, hand pumps and tap water; thus they are less affected by the worsening quality of the river water than the upland inhabitants. As a result, the risk of water born diseases is lower for livestock in the upland due to cleaner open sources than in low altitudes. Moreover, due to less access to filtered water in the upland, human disease is a more worrying factor.

Water quantity is of more importance for crop and fodder production, whereas water quality is a predominant issue for livestock productivity and human work force availability. Diseases lower productivity and have heavy economical consequences for farmers that are directly correlated to water quality and thus, its management.

4.5.4 Water and crop productivity

Crop diseases can be affected by water quality but it is not the only contributing factor. Crop productivity is a ratio between the yield and the water used to grow the plant. The RISE indicator on water productivity for plant production (WR DP1a) compares what is done in practice with standard values that are the same for all farmers. A lower water productivity in the upland can be explained by more water availability but also by the poorer yields. There are many reasons besides water for poor yields (techniques, fertilization, rotation, soil features, climate, pests, etc). However, the availability of water for the growing plant definitely affects yields. To better understand the water distribution between high-, middle- and lowland, the water balance in the watershed has to be further studied. But observations tell that:

- there is enough rainfall to produce good yields (1225-1425 mm/year);
- Irrigation during the dry season enables 3 harvests per year with providing adequate yields!
- Farmers' access to irrigation water is limited due to poor management of the access rights to pump- or derivate water;
- There is missing knowledge on the right amount of water used for irrigation. The farmer who first gains access will pump as much as possible before another one does it. The one with the biggest pump will take more than the others.
- Some existing, old irrigation systems are partially abandoned due to incorrect level alignment that inhibits a correct distribution;
- No water storage facilities are implemented to prolong the moisture period after rainfalls;
- There is no social or administrative organisation to manage this resource.

4.5.5 Farmers' practices

Even if farmers are aware of nutrient losses through rainfall on the dung piles (a question during feedbacks), no covering of these piles was observed during field work after the start of the rainy season. Already acquired technological knowledge has to be linked to a certain awareness of the danger for the sustainability. The fact that taking care of these nutrients not only saves water bodies from being polluted and reduces the risk of disease but also improves the nutrient cycle must be reinforced (see Chapter 4.8.3).

In addition, household use of soap and wastewater for washing clothes was assessed. There is not significant difference between the 2 altitudes. 69% of the farmers' wives throw the wastewater onto the soil and use natural soap stemming from the 2 kinds of soap bushes that grow naturally; the remaining 31% wash clothes in the river, using chemical soap.

Different common grazing areas that feature a swamp were observed. The animals drink from the swamp with their legs half submerged. This is a source of disease. Moreover, a potential is missed to properly irrigate the area and increase its fodder productivity. In general, animals can access any possible entrance into water bodies like, e.g. rivers and shallow wells; only wells and hand pumps are fenced off or have controlled access. The only infrastructure of water management, apart from wells and from NGO installed hand pumps, is some basic irrigation channels. No system was observed to manage livestock access to drinking water. No facilities were seen to store water at small or bigger scale, which is understandable because of the year round access to drinking water. The only interest to store water would be linked to irrigation systems for increased crop and fodder productivity.

4.5.6 Recommendations

1. Keep soil cover and use plants to conserve soil structure to avoid natural compaction.
2. Select crops also using this criterion of low evapotranspiration
3. Support creation of water hand pumps in the upland to lower human diseases pressure.
4. Creation of local associations to manage water resources for livestock in combination with irrigation to avoid water pollution. GTZ has established a successful process for this.
5. Stimulate production and the market chain of natural soap to replace chemicals. Ecological impacts of these products should be assessed first.

6. Create social- and administrative official associations to organise people around water resources. Mobilize human labour resources to implement water storage facilities, irrigation plans and implement rules for fair use. Link this project with the option of land consolidation and cadastral planning.
7. Implement solutions to divert river water to animal drinking ponds whose flow continues into irrigated plots. No dung is lost and crops will benefit from nutrient enriched water. (This idea was discussed and positively accepted by the farmers during feedbacks, but group dynamics failed to start any project).

4.6 Soil

The soil indicator looks at the physical conditions such as pH, salinization, water logging and soil sampling. An erosion index is created based on observed erosion signs, surface stones, slope, arable soil depth and counter measures against erosion. It also takes pesticide practices into consideration, proportion of cultivated surface and nutrients depletion.

4.6.1 Results

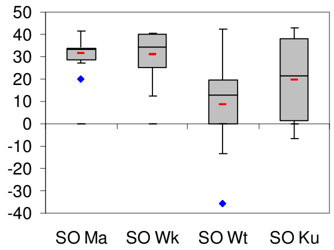
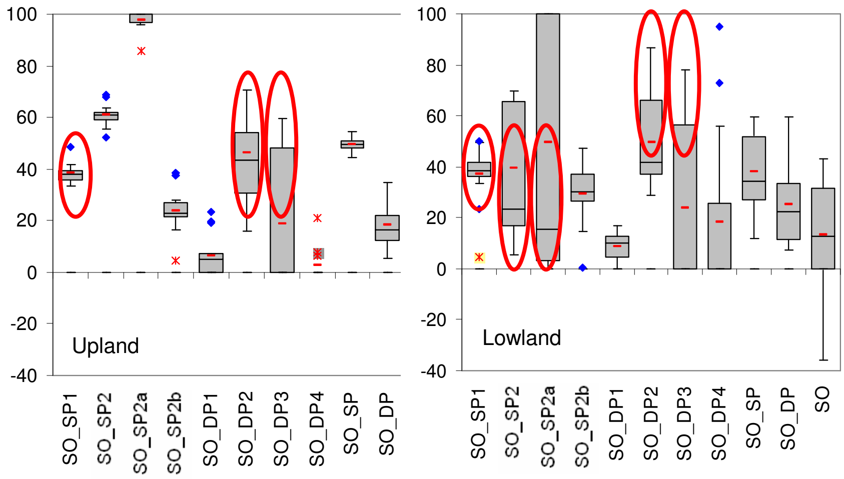


Fig.17: Soil indicator from the 4 PAs (Ma= Maynet; Wk= Worken; Wt= Woreta; Ku= Kuhar)

As shown in Figure 17, soil sustainability is positive for most of the farmers. The lowland (the 2 at right, Woreta and Kuhar) is less good and shows more variation. The lowland exhibits the worst result and is fully represented in Figure 18 with all indicators, whereas the main differences compared to the upland are shown at the left of this Figure.

Visible erosion (SO_SP2a) and danger of erosion (SO_SP2b) for the upland are less spread and averages are situated at a higher position than those of the lowland. The indicator average on proportion of soil under cultivation/tillage (SO_DP2) and salinization due to irrigation without proper drainage (SO_DP3) for the upland is also a little lower due to less- or no drainage and some wetness damage on irrigated plots.



SP= State Parameter; DP= Driving Parameter; dash are means and dots are outsiders; circles show bad position of the indicator.

SO	Soil indicator
SO_SP	Soil (State parameter)
SO_SP1	Soil pH, salinization, water logging, soil sampling
SO_SP2	Erosion index
SO_SP2a	Visible erosion
SO_SP2b	Erosion danger
SO_DP	Soil (Driving parameter)
SO_DP1	Floor loading with pesticide application or acidifying fertilizers resp. containing heavy metals
SO_DP2	Proportion of soil under cultivation/tillage
SO_DP3	Salinization due to irrigation without proper drainage
SO_DP4	Nutrient depletion (exhaustive cultivation)

Fig.18: Soil parameters of the upland (extract at the left) and the lowland. The rest of the upland indicators are similar to those of the lowland.

4.6.2 Discussion

Farmers in the lowland have 2 kinds of plots, i.e. those in the flooded area which are flat, without signs of erosion, no apparent stones and with a deep layer of arable soil, used to produce rice for a cash crop. They also have fields on weak slopes of more Nitosol beige soil, less depth that are exposed to a higher risk of erosion (SO_SP2b goes down). People in the upland have only this second kind of plots. The proportion of flat- or hilly land owned by the farmers living in the lowland is the reason for the spread of indicators for the lowland
average of the erosion indicators should be better than those for the upland. This is, however,

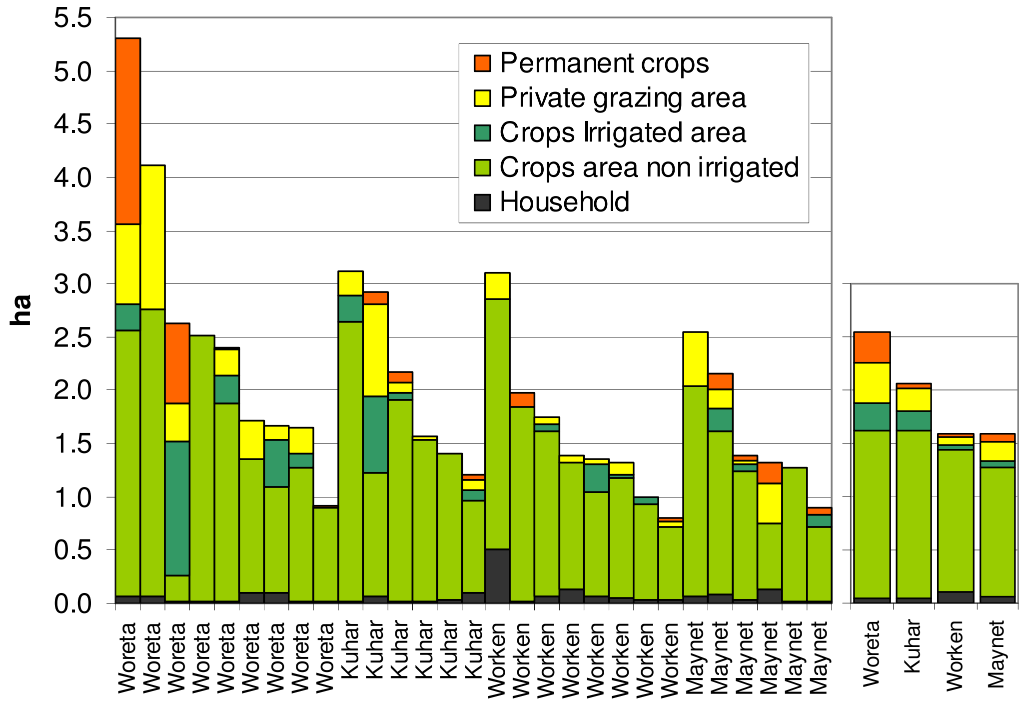


Fig.19: Repartition of land use per farmer in each PA. Flooded area are shown on the right hand side, on the left is in the non-irrigated part. At the right is the average per PA.

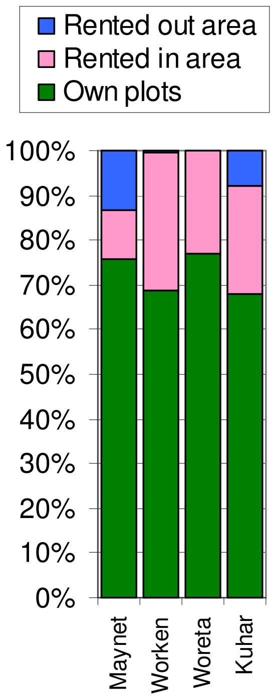


Fig.20: Repartition in percentage of kind of land ownership per PA.

not the case. The lowland sub-indicators point towards increased salinization (SO-DP3) and nutrient depletion (SO_DP4) , and slightly increased chemical and mechanical loading (SO_DP1/2), whereas the upland shows an increased risk of erosion (SO_SP2). The pressure on soil due to cultivation intensity in the lowland is less sustainable than that for the upland, despite the higher risk of erosion for the upland.

Figure 19 shows the repartition of land use for each farm and PA; their averages are indicated on the right. No correlation was apparent between these repartitions and number of workforce, amount of work on plots, biodiversity, N&P management, incomes, best general indicator, TLU/ha,… It possibly means that the farm results are not dependent on plots' type of use. Figure 20 shows that an average of over 25% of farmed surface is rented. 59% of the farmers interviewed rent in plots, 24% rent out plots and 14% do practice both. PAs with most rented out plots (Maynet and Kuhar) are situated further away from town than the others (Worata and Worken). Far PAs probably rent these fields to farmers located nearer the town. The reason could be that pressure on the land is higher near town, i.e. the cities' surface development increases the pressure. Further analysis could be done to find out other particularities of farmers with rented and let plots.

Part of the erosion danger is due to cultivation intensity, which relates to soil cover. Table 6 gives an example of the number of times farmers plough one plot. Irrigation allows sometimes up to 3 crops per year (potato, onion) and can bring about a cultivation intensity of 13 ploughings per year, which is a very high number. The farmers argue that this amount is necessary to get a fine seed bed, to alleviate soil compaction and to combat weed growth. From the point of view of ILRI, this amount is not needed. No-till technology is known but rarely used, probably due to the strong growth of weed and lack of knowledge. This intensity is also driven by the pressure to produce more.

Non irrigated	Number of ploughings	Irrigated	Number of ploughings
Wheat, Barley, peas, maize, tomato	3-4	Tomato	4
Rice (flooded)	3-4	Rice	8
Paper	4-6	Onion	3-7
Potato	3-6	Potato	6-10
Teff, sorghum, finger millet	5-8	Teff	7

Table 6: General number of ploughings per crop type in the Farta and Fogara regions.

Increasing crop productivity should also include lowering the amount of ploughings. This would not only save time and labour but would certainly alleviate the destruction of soil structure. A productive soil cover (fodder, fallow) can retain water, filter water, stop run-off, enhance biological soil life, elongate roots, rebuild soil structure to alleviate the compaction phenomena, and produce more fodder for livestock. The dilemma is the urgent need of producing cash crop as opposed to long term investments in productivity.

The pressure of having to produce increasing amounts of food enforced by habitual non optimal practices, move farmers away from applying efficient technologies, it is a vicious circle. This situation also obliges farmers to reduce till abandonate the fallowed surfaces. As a result, the proportion of tilled areas is too high (SO_DP2). There are 2 possible options to change this high cultivation rate:

- Changes in crop technology to lower the number of ploughings,
- Increase in grazing area, fallow land and permanent crops that are not ploughed.

4.6.3 Recommendations

1. Introduction of cultivated fallows or 2 to 3 year-meadows to let the soil recover its structure, while producing fodder for animals. Inclusion of the present private grazing area into the rotation.
2. Education of the farmers concerning the right balance between plot configuration, fodder production and TLU pressure.
3. Reinforcement of the erosion measures implementation, i.e. productive hedges on terraces, fodder hedges that follow the landscape contours to stop run-off, small scale irrigation techniques or any of the techniques described in the complete guidelines of Hurni H. (1986)
4. Providing knowledge on techniques that lower cultivation intensity by using better plant protection techniques (more diverse rotation, correct rotation, intercropping, weed control, composting, livestock park rotation,…). Teaching and following-up of farmers in the use of no tilling practices.
5. Support projects like those from GTZ to stop gullies formation through rehabilitation with newly planted local vegetation, fence off their surrounding and organise a local management to make the population observe environmental protection rules.

4.7 Biodiversity

The biodiversity indicator assesses the farming methods used at plot- and crop level to determine how far biodiversity is promoted. The proportion of extensively cultivated areas and plot size also plays also a role in this indicator.

Farmers usually follow general habits. As a result some questions on the techniques used to manage plots were not asked systematically, others were changed to fit the context. For example, conservation headlands are not cultivated due to the small plot size and the high cultivation intensity, the option on gentle mowing of pasture is always chosen because this does not expose the fauna to mechanisation stress. A low stocking rate is difficult to evaluate and thus the question on its value was changed as follows "Is the grazing area saved from overgrazing?" The aim was to include actual local techniques and habits into the available RISE entries on biodiversity. For further examples and details, see Appendix 1 on "Changes and justifications".

4.7.1 Results

Figure 21 shows an overall average of the biodiversity indicators below zero with a slightly better position for the Worken PA at approx. 8. State parameters BD_SP1 state by how far the farming system promotes biodiversity (Figure 22). Woken obtains better results than Maynet, which is located on the adjacent hill. In general, this promoting farming indicator is poor and indicates that no real activities are directed at favouring biodiversity. There are too few diversification elements (ecological zones: trees, either dead or alive, stone piles, hedges, ravines, wood piles, holes etc.) present in and around plots (valuable plot margin). As farming techniques, low mechanisation that decrease mowing violence and low harvesting speeds are positive for sustainability, whereas overgrazing and little variety in grass species in pasture fields are negative but not sufficient to counterbalance the two first techniques. The very few farmers that harvest hay do it after flowering, a good point that stresses the importance of continuous education.

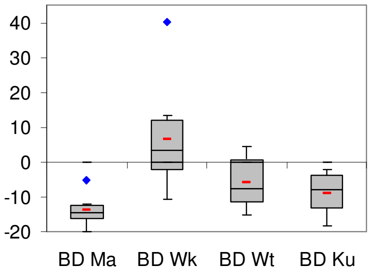
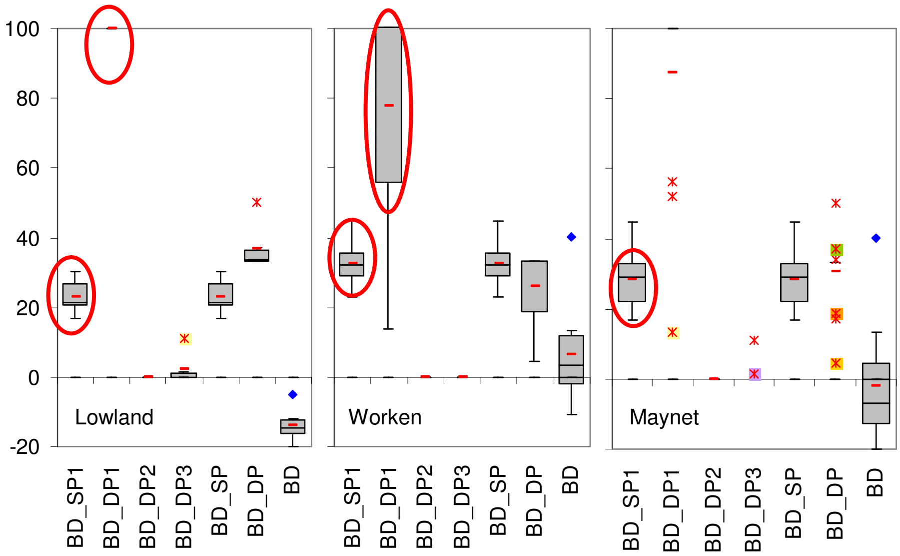


Fig.21: Biodiversity indicator from the 4 PAs (Ma= Maynet; Wk= Worken; Wt= Woreta; Ku= Kuhar)

BD_DP1 indicates the proportion of extensively used farm area and is mostly a high driving force with some exception in Worken. The RISE model definition of an extensive plot is a plot that accumulates over 70 points of biodiversity promoting farming methods applied to it (assessed by BD_SP1).

The plot size (BD_DP2) is inherently good due to the fact that Ethiopian farmers cannot manage greater farm areas due to limitations through low mechanisation. Biodiversity depends on the number of plots and number of species cropped in the rotation. If there is only one crop type cultivated, the plot size tells nothing about diversity improvements. If plot margins between these fields are elements to increase diversity, their widths have to be assessed. In the area of the study, plots margins sizes tend to a foot width without vegetation. As a result, it is suggested that the actual plot size indicator (BD_DP2) should be linked with crop rotation.

4.7.2 Biodiversity and correlations



SP= State Parameter; DP= Driving Parameter; dash are means and dots are outsiders; circles show bad position of the indicator.

BD	Biodiversity indicator
BD_SP	Biodiversity (State parameter)
BD_SP1	Biodiversity promoting farming system
BD_DP	Biodiversity (Driving parameter)
BD_DP1	Proportion of intensely used farming area on total area
BD_DP2	Plot size
BD_DP3	Weed control

Fig.22: Biodiversity parameters of Maynet (right), Worken (middle) and the lowland (left).

Figure 23 depicts farm diversity features of the farms like, e.g. the number of plots, crop rotation diversity during the last three years and the number of different permanent crops (bubble size, from zero to eight). The sample size is too small to allow elaboration of significant trends per Peasant Associations. The two farmers having only two crop types are rice and chick pea producers. Maynet (yellow circles) seems limited to have crop diversity (max. six), whereas Worken (orange circles), located at the same middle altitude, is able to implement more crop diversity with a smaller number of plots (between seven and eleven). Woreta, in blue, covers the whole range.

The strong correlations between the three factors that are illustrate in Table 7 suggests that the number of plots could be a condition that allows more crop diversity, but there is no clear causal link that can be made between them (large surface covered by the circles). A reason for this could be that with an increasing number of plots, the more the farmer can afford to lose the harvest of a trial or of a special crop (in the rotation or as permanent crop); in other words: the more he can take risks without loosing some of the main revenue, the bigger his confidence to bio diversifying. This risk calculation is related to available assets in kind and money, the residual overall gain if a trial or specific crop is lost, knowledge and confidence. Other factors can affect the choice of diversifying the farm, e.g. market situation, social trends, given agricultural conditions (nature of soil, fertility, slope, distance etc.). Correlations between this diversity and financial performances are discussed in chapter 4.12.3.

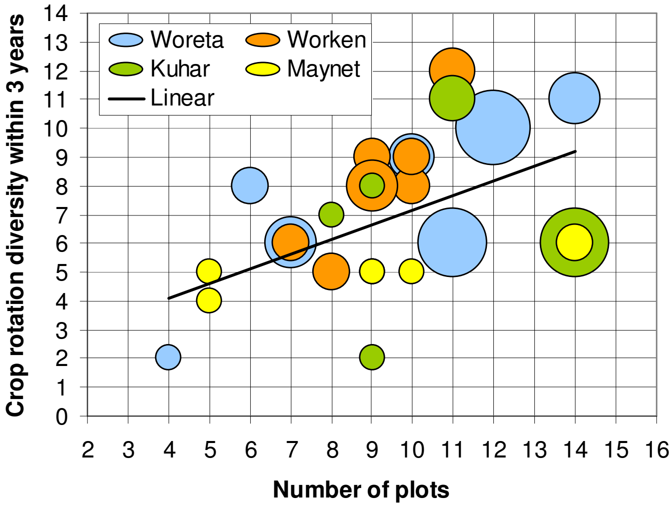


Fig.23: Visualisation per PA of the production diversity by looking at the number of different crops produced within 3 years (Y), the number of plots (X) and the amount of different permanent crops (bubble size, 0 to 8).

R^2	Number of plots	Crop diversity
Crop diversity	62%**	
Permanent crops	53%**	45%*

Table 7: Relevant correlation coefficients between number of plots, crop diversity and permanent crops. ** Significant at 0.01 level; * significant at a 0.05 level

A more in-depth statistical analysis shows that farmers have not bigger plots if they have more land; they prefer to keep the size constant, probably due to a balance between time needed for labour with available mechanisation and crop planning.

4.7.3 Biodiversity and land pressure

Biodiversity is one of the first assets that suffers during a regression of social development, i.e. when food production starts to be insufficient to serve the population. The only way to save biodiversity (diverse rotation, fallow, not overgrazed meadows, natural forests, valuable plot margins, hedges, lonely trees, marginal areas,…) from increasing cropping surface demand due to population growth and more unstable climate conditions, is to increase the productivity of these cropping surfaces. Biodiversity can only be successfully promoted when most of the food demand is satisfied. Biodiversity can also be promoted when market oriented projects introduce profitable new varieties, like the hundred million trees planted in Bangladesh as a social insurance scheme (Heierli 2000).

During the feedback dialogues, most of the farmers showed some knowledge concerning the advantages of having biodiversity in terms of natural plant protection. They also cited the following advantages: additional assets, medicinal plants, decreasing erosion, additional fodder production from trees and shrubs, wind breaker and humus builder. External pressure, however, together with the factors listed above that have shifted the topic of biodiversity into the last position of their worries. The reasons mentioned were: lack of time, lack of knowledge, lack of work force and increased risk of theft of any special assets. The risk of theft increases with increasing distance of the plots from the homestead due to difficulties in policing (see Chapter 5.2).

The arguments concerning time and lack of work force were not validated by the survey (see Chapter 4.14.3) and priorities were not directly assessed. A closer scrutiny of working time spent for agricultural purposes (3.7 days of 8h work per week, see Chapter 4.14.3.5) and the proportion of household expenses spent on ceremonies (70.1% in lowland and 85.5% in upland) suggests that religion, together with cash crop production, seems to come first while landscape enrichment plays a subordinate role .

During the last year and with increasing demographic pressure, the spaces between plots became thinner and thinner until they are often no longer perceptible or not broad enough to lead a herd or the two ploughing oxen to the fields. This creates new conflicts[10] through the destruction of part of the cultivated plants that encroach on the path. It illustrates the pressure on biodiversity due to the surface needs to produce food with the currently applied technologies.

Improving biodiversity must be strongly linked to the prospect of new income and a strategy to increase assets as a financial insurance, similar to livestock, as well demonstrated in the book of Heierli (2000) Poverty alleviation as a business. If such a strategy can be found, the importance of livestock could decrease with less pressure on communal grazing areas and thus less erosion for more productivity of natural fodder resources. Technological resources should be invested in biodiversity and its value chain to support household incomes, insurances and livestock production.

4.7.4 Recommendations

1. Creation of associations to increase the value of local production of these "new" assets (natural soap, medicine, new beverages, tree-fodder production etc.) and assure value chains. Stimulation of local knowledge about such past assets using participatory methods. Creation of diversity in needs to stimulate the demand for local products.
2. Linkage of the biodiversity of new assets with ecological advantages and prove it through trials with farmers (See the six successful examples from Heierli 2000).
3. Alleviation of limiting factors to keep biodiversity through:
    a. Enhancing surveillance capacity by reducing the number of scattered plots (see Chapter 5.2);
    b. Providing farmers with access to knowledge concerning each valuable new species through extension agents and NGO work.

4.8 Nitrogen and Phosphorus potential emission

This indicator indicates the risk for nitrogen and phosphorus emissions stemming from manure, silage and fertilizers application into the air and water. Animal excrement production and import of nutrients (fertilizers, straw) are compared with export and yields to determine the balance of these two nutrient cycles. Fertilizers used by the farmers in the studied area are the soil acidifying Urea (60:0:0)[11] and the better balanced DAP or Diammonium phosphate (18;46;0).

[10] Recent conflict phenomena explained by Dr. Welatu Tadesse from ARARI centre, Bahir Dar
[11] (N : P_2O_5 : K_2O)

As explained in Chapter 4.4 on energy and household energy consumption, amounts of nutrients in fuel (dung and wood) used in households are included in the calculation of this balance as nutrient exports. Dung that is not produced on the farm during grazing on communal areas is also taken into account in the balance by the RISE model as time spent on and off the farm area.

4.8.1 Results

As shown in Figure 24, the averages N+P indicators of all 4 PAs are negative. This particularly applies to the upland. Figure 25 shows in detail that the two state parameters (SP1/2) are particularly bad and one of the driving forces is high (NP_DP1).

In general, the nutrient balance (NP_SP1) of most farms shows a surplus in nutrient production stemming from the animals compared to crops needs. Figure 26 shows in more detail the relation between the N-total balance and animal pressure in TLU per arable area.

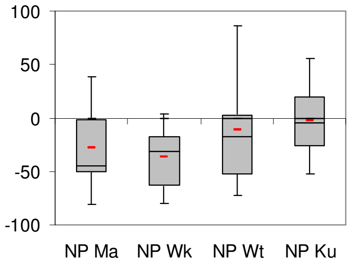
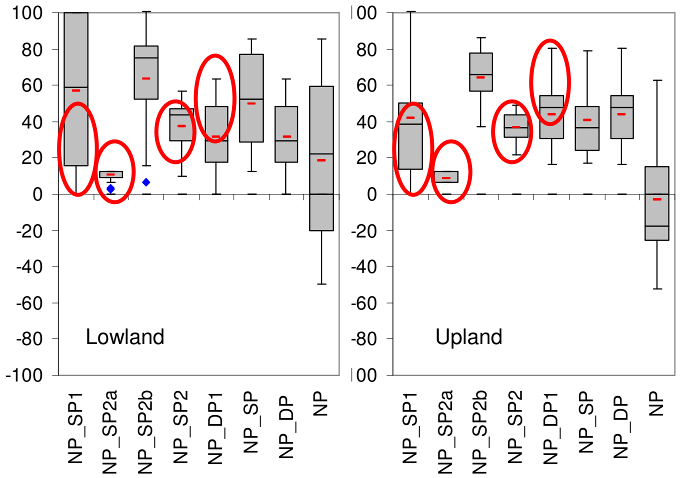


Fig.24: N and P potential emission indicator from the 4 PAs (Ma= Maynet; Wk= Worken; Wt= Woreta; Ku= Kuhar)

Manure storage is a problem. NP_SP2a is low and indicates that storage facilities have leakages because the manure is laying on bare soil and is not protected from rain. Dung cake piles and compost do not produce juices, like litter does, without additional water. They remain, however, unprotected from rain that leaches nutrients. Insufficient measures are put in place to cover and protect the dung piles from this exposure.

The availability of nutrients (N and P amount available per total farm area) is described by the NP_DP1 driving force which is in general too high. This means that again, a too high amount of N and P are produced compared to the farm surface. This amount comes from animals, includes the purchase of fertilizers and subtracts any export of nutrients recorded.



SP= State Parameter; DP= Driving Parameter; dash are means and dots are outsiders; circles show bad position of the indicator.

NP	N and P emission potential
NP_SP	N and P emission potential (State parameter)
NP_SP1	N & P balance by production and demand
NP_SP2	Manure storage and application method
NP_SP2a	Manure storage
NP_SP2b	Application method
NP_DP	N and P emission potential (Driving parameter)
NP_DP1	N & P from organic and inorganic fertilizers (imports/exports)

Fig. 25: N&P potential emission parameters of the upland (right) and the lowland (left).

4.8.2 Origins of the unbalance

The results show a too large amount of nutrient production compared to crop demand or crop yields that are too low in relation to the available fertilizers stemming from animals. The main factors influencing the balance are mainly animal production as provider and the crop yields as consumers. In the upland and lowland, 3.6% and 12.7% of N used is imported while 11.2% of P is exported in upland and 1.7% comes from imports in the lowland. The true numbers, however, should be a bit higher. This distortion is due to data problems expressed in Chapter 4.2.1, that artificially enhances livestock nutrient production. The results, however, show, that the lowland imports more fertilizers than the upland and that P losses occur in the upland. A good balance is near 1. This balance is 38% significantly correlated (R^2=0.378) to animal density on the farm, as shown in Figure 26. Livestock, crop and fertilizer types determine the deviation from the linear regression line.

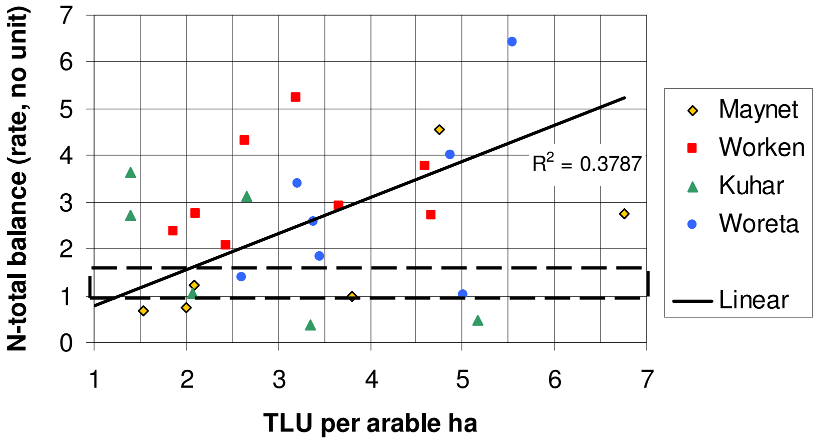


Fig.26: The relation between the N-total balance and the cattle pressure in TLU per farm arable ha grouped by PA. Points in the dashed area show the region of ideal management.

The biases (inadequate livestock data, yields data) on the calculated N and P balance amplify the unbalance (higher slope of the regression curve of Figure 26). This is, however, not influencing the good correlation between animal pressure and the balance. In other words, herd and nutrient management stay the same even if farmers have more animals per ha. A good management is around 1 and would give a flat regression line at 1 on the y-axis even if animal density increases on the farm (in the dashed limit zone of Figure 26).

Table 8 presents the main differences in nutrients flows found in the balances between up and lowland. The lowland has a more intense turnover of nutrients. 37.3% more N substances than in the upland are exported through yields in the lowland while inputs are 20.3% higher. There is a possibility that the numbers of the average balance in kg are wrong due to data set used, but tendencies shown are correct and tell that the upland is less balanced and lowland has a loss of P_2O_5.

	Difference in nutrients flows in lowland as compared to upland		Average balance in kg	
	inputs	outputs	Lowland	Upland
N	+ 20.3%	+ 37.3%	38.0	53.5
P2O5	+ 10.1%	+ 30.2%	-10.6	12.6

Table 8: Differences between input and output, N and P and the low- and upland.

Good data that is fitting local reality would probably bring a more sustainable position of the indicator for all farmers. Note that dung losses on the way to scattered plots are not included (oxen for ploughing on remote plots, herd lead to private grazing- and drinking areas), the losses from dung pile leaching too cannot be taken into account. These amounts can also affect the global balance. Here, their influence on the balance is positive but these losses can not help to improve the result of crop yields. Note also that nutriments taken out of all the fields are not necessarily coming back via livestock dung at the same place, but will be redistributed near the household, increasing fertility differences between the plots. RISE ignores this phenomenon.

Figure 27 shows the balance between N and P in percentage. Results situated in the dashed circle or situated nearest 0% are good. A positive percentage means that the amount is a surplus at this percentage. The good balance between producers and consumers centralise points near zero (circle in Figure 27). This figure illustrate the large spread of farms with unbalances, only three to seven can be considered as more or less balanced (<50%). Mostly all are exceeding in N more than in P (above the dashed line). Using a representation in kg would require the adjustment of numbers to the farm area to see impact intensity of the unbalance. Further analysis could be done to determine how to manage animal, crop and fertilizers types to get an optimal balance between N and P.

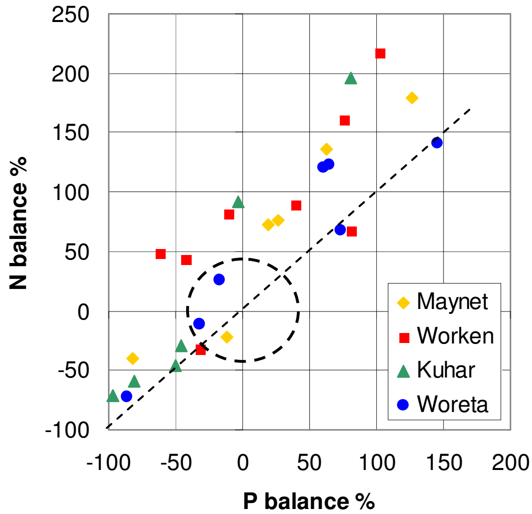


Fig.27: Balance comparison of N and P in % due to livestock types, crops harvested and kind of bought fertilizers. Good is to be in the dashed circle.

4.8.3 Animals' categories

Figure 28 shows the distribution of animal categories between the two altitudes. Bovine density decreases from 89% in the lowland to 61% in the upland and probably amounts to even less at higher altitudes. At medium altitude, bovines are replaced by ovines and caprines. There is, however, no presence of caprines at higher altitudes as they are unable to survive at lower temperatures. The upland farmers breed horses and mules (20% and 6% TLU respectively) to replace the more readily available motorised vehicles presence in the lowland. Free range pigs were observed in proximity of Addis for tourist food supply and camels are found south and south east of the country but not in the studied area.

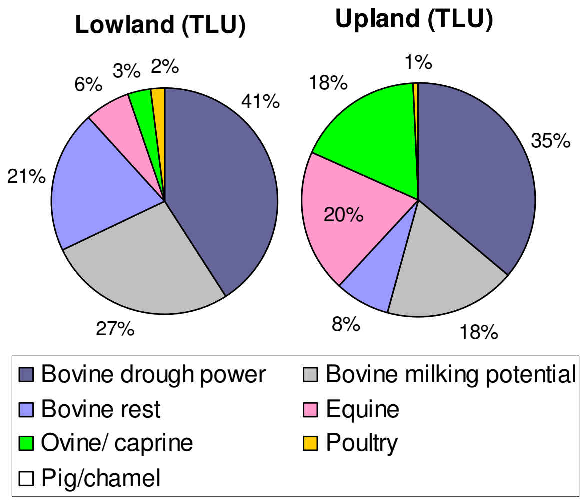


Fig.28: Distribution of livestock types in the low- and upland.

A good management between nutrients production and demand, with a high number of animals per surface, is possible and should theoretically keep the balance through the export of more nutrients or production of higher yields. This should be feasible by:

- Use manure as fertilizers;
- Composting: the process looses nitrogen but increases the chemical and biological diversity of the final valuable fertilizer;
- Reduction in number of herd heads per ha;
- Increase of crop productivity by changing cropping methods;
- Sale or burning of manure. This option, however, is not recommended as there is a need to increase soil fertility.

4.8.4 Recommendation 1: Reduction of the herd size

In theory, there are three strategies for managing this unbalance. The first option is the *reduction of herd size* per farming area and farmer. This would be difficult to achieve as livestock represents a big resource for this rural population like, e.g. drought power, meat, milk and skins, transport, economical insurance, prestige, etc…

Herd size is driven by death rate, market opportunities, basic products and services needed by families. Limiting factors are sickness, the availability of fodder and its quality, feed regime and water quality. Vaccination is a strategy to only lower the impact of diseases impacts. Water quality is an important issue for avoiding diseases. Fodder availability depends on livestock pressure or grazing area management and fodder species. There are no indications whether access to more fodder will also increase livestock production (amount of heads) instead of its productivity (quality).

Market prices reward farmers regarding the quality of their products. The increase of profit through a better quality seems insufficient to motivate them to lower the herd size. Other social aspects have to be taken into account, like insurance, livestock product value chain. Discussions with farmers on biodiversity suggested using biodiversity to increase the safety net and motivate the farmer to more easily reduce his herd size. Lowering herd size can affect drought power and can be counterbalanced with crop techniques lowering intensification. The potential to develop simple agricultural machines exist, they could also lower plough intensity by providing a good seed bed with less plough passages.

Health and quality of the animals is related to fodder access which is actually more or less assured by private and common grazing areas and crop residues. The use of common grazing areas follows the strategy of accessing the least expensive fodder resource possible: both access and use are free of charge, and thus no feedback from this element goes back to the farmer to oblige him to manage his herd size differently. Awareness already exists concerning the pressure on grassland and the 2 typical futures of these free grazing areas: weed invasion (*Hygrophila auriculata*) and gully formation with surface, soil and fertility losses. See chapter 5.3.1 for more information on herd size management.

4.8.5 Recommendation 2: Increase of crop/fodder productivity

The second strategy is the *increase of crop productivity*. It is linked to lots of factors like market opportunities, knowledge and extension strategies, time spent for agricultural purposes, customs and social pressure, used technologies, labour to invest, price security, motivation etc. Observations show that there is a potential to substantially increase production per farm. Any strategy implemented should strengthen the following factors:

- Stabilise water availability over the year;
- Avoidance of soil losses from erosion, increase soil fertility;
- Ameliorate crop protection;
- Support of trials and implementation of new varieties;
- Access to improved seeds;
- Access to useful knowledge for increasing crop production in a holistic and sustainable way;
- Assure market prices or secure incomes;
- Administrative support of the value chain creation;
- Lowering labour intensity through land consolidation;
- Increase in working hours spent for agricultural work;

- Stimulation of motivation and group dynamics through messages and support from PA, Orthodox Church, government and NGOs.

In practice, obvious techniques must be implemented like, e.g. composting, livestock rotation on fields combined with residue valuation and fodder production; here labour is a limiting factor. The other above mentioned conditions show that increasing crop productivity is dependent on several changes for society, ranging from market conditions to social habits, from resource management to administration support. Natural resources, however, like soil quality and water are plentiful and are readily available for increasing production.

The third strategy is a mix between lowering herd size and increasing crop productivity. It is possible to make precise recommendations concerning the improvement of the nutrient cycle balance (composting, fodder hedges, vegetal terracing etc). These, however, are already known and tested, providing mediocre results. It makes more sense to look at this balance as a downstream indicator of the overall system that can only be efficiently managed by a group of measures implemented in different domains and supported by different social and economical actors. The main entry points proposed in this thesis work this way.

4.9 Plant protection

The plant protection indicator looks at the quality of chemical application, assesses the environmental and human toxicological risks and crop rotation as a means to reduce pest and disease pressure. The main chemicals used are the 2-4D Dimethenamid, a herbicide of the chlorophenoxy acid class which has a moderate toxicity (WHO toxicity classification II = moderately hazardous = Rat LD50 of 50-500mg per kg body weight) and the fungicide Malathion from the organophosphorus class which is slightly more toxic than 2-4D. Both chemicals are carcinogen and affect aquatic life (Pesticideinfo 2008).

4.9.1 Results

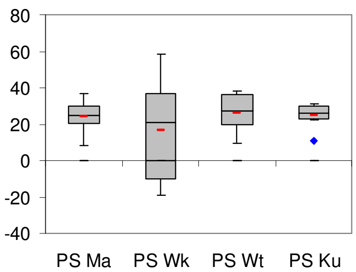


Fig.29: Plant protection indicator from the 4 PAs (Ma= Maynet; Wk= Worken; Wt= Woreta; Ku= Kuhar)

The average of the plant protection indicators for the 4 PAs are very similar (Figure 29) with the exception of the Worken PA in the upland. Figure 30 shows the results in more details and analyses the differences between the 2 altitudes.

The parameter PS_SP1 of actual conditions regarding the quality of application is good; people are well trained on the correct use of chemicals. Last year, ILRI provided modern sprayers and training for the use of equipment and chemicals. The careful use of these 2 chemicals that are of moderate toxicity fix the second parameter PS_SP2 on toxicological risks in a positive position. But N fertilisation (PS_DP1a) remains high due to the unbalance explained in Chapter 4.8 on the nutrient cycle. This lowers plant vigour and makes them prone to diseases. A positive factor is that very few areas are subjected to pesticide application (PS_DP1b).

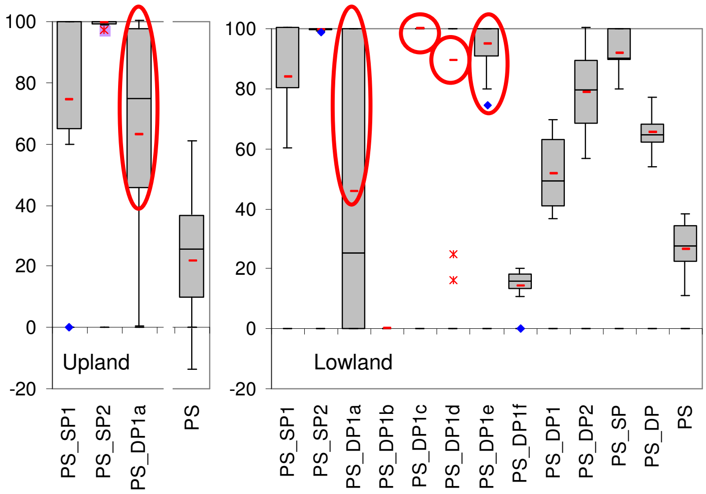


Fig.30: Plant protection indicators of the upland (left) and the lowland (right).

SP= State Parameter; DP= Driving Parameter; dash are means and dots are outsiders; circles show bad position of the indicator.

PS	Plant protection indicator
PS_SP	Plant protection (State parameter)
PS_SP1	Quality of the application
PS_SP2	Environmental and human-toxicological risks
PS_DP	Plant protection (Driving parameter)
PS_DP1	Cropping systems
PS_DP1a	N-fertilization (over saturation)
PS_DP1b	Proportion of area under pesticide application
PS_DP1c	Variety selection
PS_DP1d	Damage threshold, prognosis systems
PS_DP1e	Biodiversity
PS_DP1f	Other relevant measures
PS_DP2	Crop rotation

The use of different crop varieties to combat pest pressure is low (PS_DP1c) and thus it lower potential for plant protection. High PS_DP1d indicator about the damage threshold indicates that farmers who use chemicals use these in a systematic manner but without taking into account thresholds or using prognostic systems.

Biodiversity helps plant protection. The farmers are already aware of this. The PS_DP1e indicator of the RISE model looks at the biodiversity of ecozones related to plots and diversity of permanent crops. Its high position in Figure 30 means that there is insufficient biodiversity for all plots which are used intensively and lacking valuable plot margins (see Chapter 4.7).

4.9.2 N-balance

The nutrient cycle, viewed from a different angle, could explain the origin of the N over-saturation that is lowering plant protection. Table 9 shows that both altitudes have a similar livestock pressure (~3.15 TLU/ha) and proportion of farmers (~69%) that spread artificial fertilizers. However, the farmers from the lowland use almost half more fertilizer per ha (46%) than those situated in the upland.

	TLU per arable ha	kg fertilizer per arable ha	Fertilisers' users	kg fertilizer per arable ha by the users
Upland	3.3	25.0	71%	35.1
Lowland	3.0	43.8	67%	65.8

Table 9: Nutrients sources in the 2 altitudes.

Concerning N-consumption, Table 10 shows the main export (without yields) from the nutrient cycle going out for household energy consumption. The proportion of dung cakes amongst the energy carriers is almost 26% for both regions. Overall energy consumption in the lowland is, however 30% more per household or 22% per WF than that of the upland. Due to smaller farm surface for about the same family size, upland farmers exploit 15% more of their energy resources than the lowland.

	Household dung cakes consumption in kg	Part of the dung cakes in the energy consumption	Total household consumption of wood and dung cakes for energy in kg	Consumption of wood and dung cakes for energy per WF, kg/WF	Consumption of wood and dung cakes for energy per arable area, kg/ha	Total energy consumption for agricultural purpose
Upland	882	25%	3'571	792	3'274	0
Lowland	1'267	27%	4'728	1'019	2'768	0

Table 10: Consumption of the nutrient sources of the 2 altitudes excluding yields.

Higher N outputs suggest that yields are better in the lowland (Table 8). The lowland farmers use more fertilizers per ha while those of the upland burn or export more per ha from the nutrient cycle. Efficiency or nutrient management is, therefore, better in the lowland and results in a better balance. As a result, crop protection is also better (see NP_SP1 average in Figure 30). It is noticeable that there is more variation present in the lowland (NP_SP1 and PS_DP1a) than in the upland and thus tells that there is presence of both very good and very bad management. Further analysis could be possible to classify the farmers concerning their N and P balance and N-saturation into good, mediocre and bad indicators in order to identify reasons for differences in nutrient balances.

4.9.3 Species and varieties

Farmers have very little choice in the selection of varieties to adopt strategies as a means of controlling pests and diseases. The number of varieties ranges between one to three, if available on the seed market at an affordable price. Given the choice, farmers always choose the more productive variety through comparison with previous harvests, i.e., they reject varieties that failed to produce a satisfactory yield under pressures such as pest, drought or that have other disadvantages like long growing period or sensitive to cold weather (higher altitude). The farmers will only change crop species once pests have destroyed most of the production. Powerful pest management, therefore, is restricted by a lack of available varieties and the unwillingness to quickly switch species due to other factors like need of cash crops. Poor management is also due to the incorrect threshold evaluation for chemical application (PS_DP1d), no rotation management, no adaptation of agricultural techniques. The use of chemicals could be replaced by a good nutrient management, better crop rotation and also an integrated pest management (IPM). There is no awareness concerning this kind of holistic approach, i.e. choice of adapted techniques.

The government supports farmers through research centres that are investigating new and better adapted varieties (e.g. ARARI, Amhara Region Agricultural Research Institute, west of Bahir Dar). Here, the time needed to develop these varieties and the difficulties to distribute the new seeds to the farmers are major constraints. Under the current system, these new and improved seeds are sold cheaply to the farmers who are required to give back a certain amount of their harvest for continuous propagation. The farmers, however, find a way to sell the harvest instead of handing back the expected amount as a loan repayment, thus limiting the amount of seeds available for sale of the government.

4.9.4 Recommendations

Plant protection is highly dependent on nutrient cycle management and market availability of improved seeds. In addition to the recommendations listed under Biodiversity in Chapter 4.7.4, the following additional points should be mentioned:

1. Training and setting up of trials to demonstrate the benefits of better rotation and intercropping techniques;
2. Training concerning thresholds for spraying the right chemicals at the right time and right amounts;
3. Selection of nitrogen producing plants and implementation of techniques to improve the soil structure which is a determinant for plant health. E.g. young tree branches can be chopped up and spread on fields as N fertilizer and as a means of renewing the soil structure. Suitable species are Accacia cinophila, Napiergrass, Treelusser, Suspania susban, Halnes tree, etc[12]
4. Promotion of cropping techniques and herd management to increase soil cover over the entire year.

4.10 Waste management

The waste indicator assesses the management of nine different waste categories such as antibiotics, waste oil, batteries, plant protection products such as left-over spray mixture and products, all toxic substances, glass, metal and other recyclable materials (plastic), carcasses and other forms of waste. The indicator takes into account amount, kind of disposal on the farm and treatment outside the farm area (recycling etc.).

The test week allowed assumptions to fix in advance and skip some of the typical answers (see Appendix 1 Changes and Justifications). Chemicals are systematically used to the last drop. The containers containing these chemicals (mainly pesticides) are often given back to the salesperson or sometimes reused on the farm until it is no longer useable and becomes plastic waste. These waste bottles are included in the "other waste" category. Carcasses are exploited as much as possible before being considered as waste. Meat is shared with the butcher, the hide given to the dogs, the skin either sold or used to satisfy home requirements and the bones left in the open.

4.10.1 Results

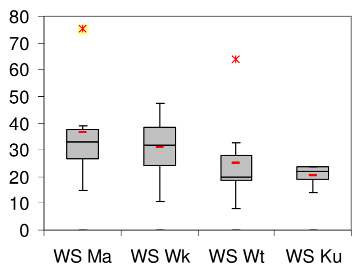


Fig.31: Waste management indicator from the 4 PAs (Ma= Maynet; Wk= Worken; Wt= Woreta; Ku= Kuhar)

All PAs have positive indicators; the upland achieved marginally better results (Figure 31). The two main problems that keep the state parameter 2 (WS_SP2) of Figure 32 quite low are the antibiotics entering the food chain and the batteries whose disposal on the farm is a problem.

As shown in Table 5 above, 80% of the farmers in the lowland vaccinate their animals, compared to 50% in the upland. Not all farmers using antibiotics are aware of the waiting time necessary to avoid the introduction of the chemicals into the food chain. Discussions during feedback showed that a few do not know, others do know but do not apply their knowledge and others apply a too short period (one to three days). The correct

[12] Personal communication from Aklilu Alemu, collaborator in ILRI.

information is spread by the Ministry of Agriculture through extension agents and vets working on site for serial vaccination.

The second problematic waste is the small batteries used to power flashlights and radios. Figure 33 shows that the amount of batteries used and thrown away onto the farmland, mainly within 10 to 30 m^2 of the household area, generally exceeds 8 pieces per year for up to 60% of the interviewees.

4.10.2 Batteries

During feedbacks, the farmers explained that they use batteries to "burn" or disinfect lesions with the acidic content. When asked if they would be prepared to swallow the acidic liquid, their facial expression was doubtful and they finally answered: "no, because of the probable toxicity". The link was then made to the children playing with these "toys" by disassembling them and tasting their contents prior to destruction. The farmers were informed concerning injuries caused through swallowing battery acid or indirect ingestion via water or vegetables grown on soil polluted by acid (progressive and irreversible skin problems, digestive malfunction, headache etc).

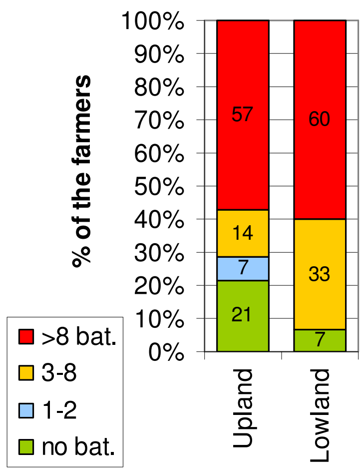


Fig.33: Percentage of farmers using a certain amount of batteries within a year per altitudes using the RISE categories.

In this region, there are no recycling facilities for batteries. Three solutions for their disposal were discussed during the feedbacks: buying less, disposal in a watertight pit, burning[13] and disposal of the ashes in hedge vegetations that are not easily reaching food chain.. The third solution suits the local mentality well.

The RISE questionnaire relates different waste amounts to arable surface or TLU. Batteries are, however, not included. The threshold that defines eight batteries per annum as being dangerous is a quick attempt and brings 60% of the farmers into a bad position. One single battery, however, that is disposed off in a well, is sufficient to severely pollute and condemn it. As a consequence, relating the number of batteries used to arable surface might not be the right approach. Questioning the probability of batteries coming in contact with water bodies, drainage, humans and livestock could be more meaningful for assessing the risk potential.

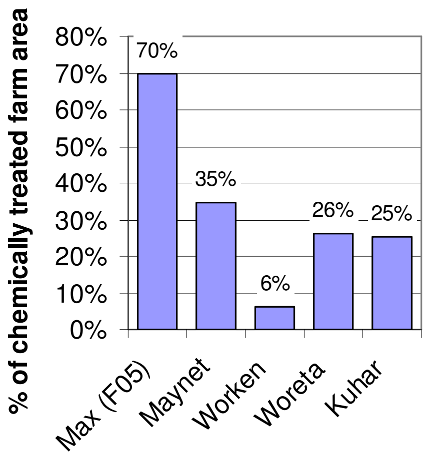


Fig.34: Percentage of farm area with chemical treatments per PA. Farmer F05 is in the Maynet group.

Water and soil pollution from batteries are not to neglect. It affects strongly resource quality. It has an additive effect along downstream water flow as well as in the soil. Contained heavy metal substances in soil block natural biological processes, create mineral unbalance, lead to fertility losses, complicate soil remediation and are found again in food chain. A deeper study should stress how far the used amounts affect water and soil resources and undermine actual efforts of improving soil fertility.

[13] Producers of batteries ask to not burn them and to use a recycling net.

4.10.3 Chemicals

Due to the high price of chemicals, farmers use very small amounts without there being any leftovers. This helps to keep the indicator in a good position. Figure 34 shows that between 8% and 35% of farm surface area is affected by chemicals, which is relatively low. The average amount of active substance spread per farm area is 0.2 litres/ha with one exception of 2.0 litres/ha in Maynet (F07); this amount is also comparatively low. The use of chemicals in the studied area is dependent on price, nature of the disease and its extent and the information farmers rely on for their application

4.10.4 Vaccination residue

The high value of livestock incites the people concerned to share and exploit all by- products of dead animals, whether they were sick or not. In the area studied, vaccination is a new technology and consequences of residuals in the food chain are not common knowledge or are not taken seriously enough into account. The reality of its wealth effect is difficult to transmit. It is difficult to convey to the farmers the detrimental effect on health of vaccination products whereas the health hazard of batteries is new but understandable due to violence of the acidity witnessed. The latter can be easily linked to real, perceived danger.

4.10.5 Recommendations

1. The extension agents could be prompted to demonstrate the health hazard of antibiotics in the food chain and battery acid in the human body through direct intake or indirectly via the environment. Right method should be further developed.
2. Import of mechanically rechargeable or solar powered flashlights and radios for example.
3. Setting-up of a recycling system for waste batteries using a depot system to stimulate the return to shops or recycling points.
4. Set an additive value on batteries prices to subsidies its recycling.
5. The price of chemicals should remain high and thus will push farmers to apply good practices that should do indirectly the work of these chemicals.

4.11 Economic stability

This indicator deals with the long-term ability of the farm to ensure liquidity and profitability. The indicator takes also into account unexpected events, state of mechanisation, number of buildings and permanent crops, together with the structure of capital.

The life span of assets was redefined to fit to local reality: tools = 5, machinery = 10 and buildings = 15 years instead of respectively 10, 15 and 30 years. Calculation of the annual depreciation, based on the previous year’s prices, was subjected to high fluctuations due to the actual inflation estimate for 2008 from 16% (Indexmundi 2008) till 39% (Bloomberg 2008). Depreciation was calculated based on the purchase or construction price, divided by the life span rate.

4.11.1 Results

Figure 35 shows that economic stability is slightly above 20 for the upland and at 0 for the lowland. This difference between up and lowland is mainly due to more investment in lowland regarding to their assets that lower their ES_SP1 parameter.

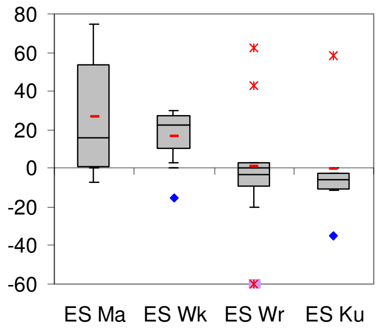
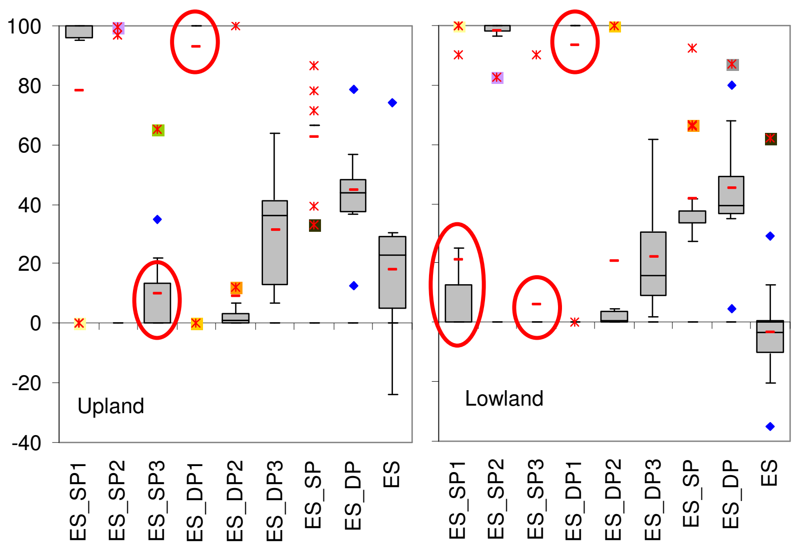


Fig.35: Economic stability indicator from the 4 PAs (Ma= Maynet; Wk= Worken; Wt= Woreta; Ku= Kuhar)

Figure 36 illustrates in more detail that there is a low net debt service over change in owner's equity and paid interest (ES_SP1), not enough gross investments (ES_SP3) and a bad ratio between cash flow and raw performance (ES_DP3).

Farmers cannot afford to have debts and thus it stops the dynamics that can be generated by investment. In addition to low income, the lack of a micro credit infrastructure and the high risk factor for creditors are the main reason for the lack of remedial action to alleviate the high poverty rate. There is very little new investment. The farmers exploit their assets until they are no longer reparable and sell livestock or crops to pay for replacements. Due to the minimal mechanisation, it is possible that no investment is necessary during several years without tool performance being affected.

The overall pressure on the farmer pushes him to use self-sufficiency strategies and informal ways to survive (labor sharing,..). This tendency is strengthened by an instable market situation or context, making the assessment of this kind of economy increasingly difficult.



SP= State Parameter; DP= Driving Parameter; dash are means and dots are outsiders; circles show bad position of the indicator.

ES	Economy stability indicator
ES_SP	Economy stability (State parameter)
ES_SP1	Net debt service over change in owner's equity and paid interest
ES_SP2	Equity ratio
ES_SP3	Gross investment
ES_DP	Economy stability (Driving parameter)
ES_DP1	Cash flow/raw performance rate
ES_DP2	Dynamic gearing
ES_DP3	Condition of the machines, buildings and permanent crops

Fig.36: Economic stability parameters of the upland (left) and the lowland (right).

4.11.2 Recommendations

A good economic stability of the farm is firstly related to margins which can be made from market sales. As soon as enough money and products flows between the farm and the market (incomes generation), the way it is managed can be then more obviously assessed. The overall situation (market, productivity, motivation) is contributing to lower amounts of money in the farmer's pocket. Money injection from financial projects, banks, government, investors, new enterprises must be channelled into projects that have positive impacts on the following 2 poles: productivity and related contributing factors and market stabilisation (see chapter 5.5).

Micro credits and other financial tools might be beneficial for increasing economic stability. Further research, however, is required to identify the correct procedure for their implementation.

4.12 Economic efficiency

The economic efficiency indicator measures the economic fitness through competitiveness and compares financial performance to available financial and human resources. Income affects all sub indicators.

4.12.1 Results

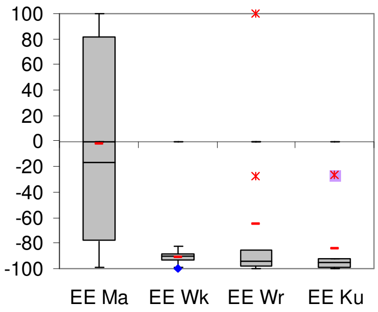
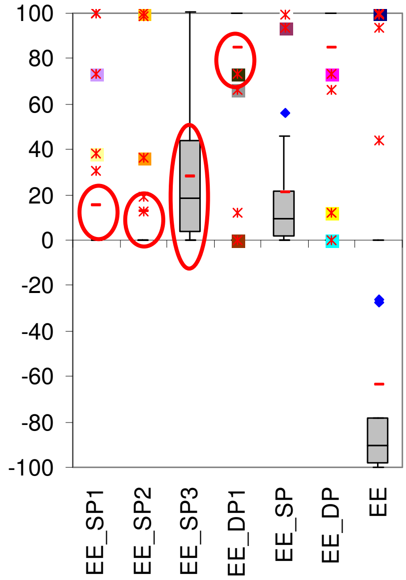


Fig.37: Economic Efficiency indicator from the 4 PAs (Ma= Maynet; Wk= Worken; Wt= Woreta; Ku= Kuhar)



SP= State Parameter; DP= Driving Parameter; dash are means and dots are outsiders; circles show bad position of the indicator.

EE	Economic efficiency indicator
EE_SP	Economic efficiency (State parameter)
EE_SP1	Return on assets
EE_SP2	Return on equity
EE_SP3	Total earned income
EE_DP	Economic efficiency (Driving parameter)
EE_DP1	Productivity

Fig.38: Economic Efficiency parameters of all PAs.

As Figure 37 suggests, economic efficiency is very poor except for the six farmers (F03, F05, F06, F09, F26, F31) who make a calculated a net profit. Three of them live in Maynet, for in the upland, the highest profit is in Woreta. Low wages compared to the total capital explain the bad position of the return of assets (EE_SP1) parameter. A similarly bad position of the parameter EE_SP2 on returns on equity indicates that there is a low rent of owner's equity compared to the owner's equity. EE_SP3 on earned incomes outlines the difficult situation of the 23 other farmers who have calculated net losses. Productivity (EE_DP1) is a high driving force and expresses a high calculated loss compared to raw performance.

The operating farm calculated as income varies between 276 Birr per year (28.25 USD[14]) and 39'764 (4'070 USD) (average of 10'154 Birr = 1'039 USD). Calculated net losses of up to -65'784 (6734 USD) prevail. Only two farmers are into profit amounting to an average of 6'690 Birr (685 USD). The 12'341 Birr (1'263 USD) profit is due to the farmer selling his milk and his part time work as a fertilizer merchant (F26).

4.12.2 Conditions of financial success

A further question was the identification of conditions that enable some of these farmers to make a profit. Calculated net profit/loss would not appear to correlate with arable area, number of working persons or diversification[15]. F26 (Figure 39, middle) achieves the best calculated net

[14] Birr = Ethiopian currency (ETB). 1 USD = 9.76915 ETB, 7/20/2008, www.xe.com
[15] Number of plots + number of different crops within a 3 year rotational period + number of different permanent crops

profit despite solely cultivating cash crops like e.g. rice and having the lowest level of biodiversity amongst the interviewed farmers. The other profitable farmers too only grow a limited number of different crops, i.e. up to 6 different crops. This means that in order to benefit from current conditions, priority must be given to cash crops, a strategy that amplifies the present lack in market produce diversity (see Chapter 5.4.1).

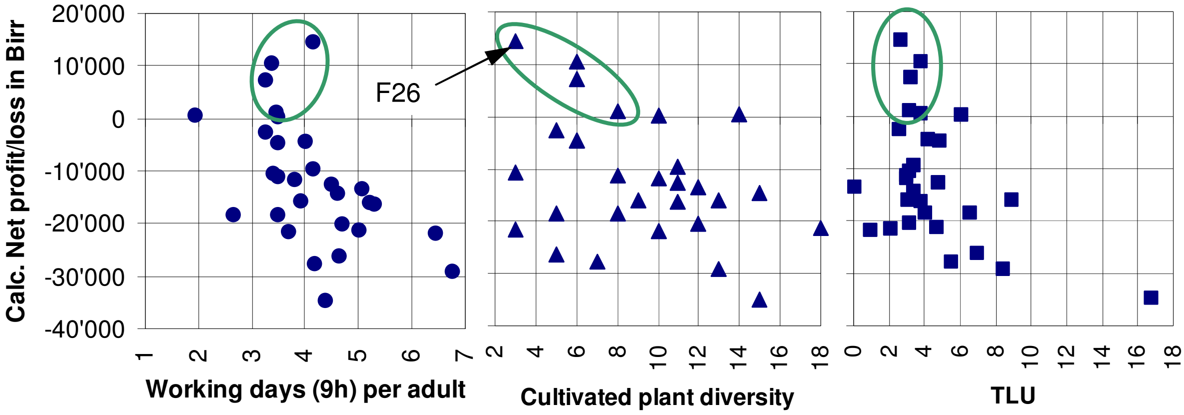


Fig.39: Three obvious tendencies of the for profitable farms (in circles): working days (9h) per adult, cultivated plant diversity and TLU

Figure 39 on the left side indicates that profitable farmers invest 3.2 to 4.2 nine-hour working days per week and adult. There is no apparent correlation between total working time, working time per ha and working time per working person. This working rate seems to be advantageous due to the use of efficient working practices and strategies. Another apparent optimum is the TLU managed by the farmer situated between 2.5 and 3.7 TLU per ha. For other farmers fulfil these same three conditions but at a loss. This analysis shows that 60% of the farmers who fulfil these three conditions are doing profit with the current, non-sustainable situation. All of the six farmers from Maynet fulfil two or three of these conditions but only half of them are profitable. It is possible that more in-depth research could pinpoint other conditions and reasons that link Maynet to potentially better profits.

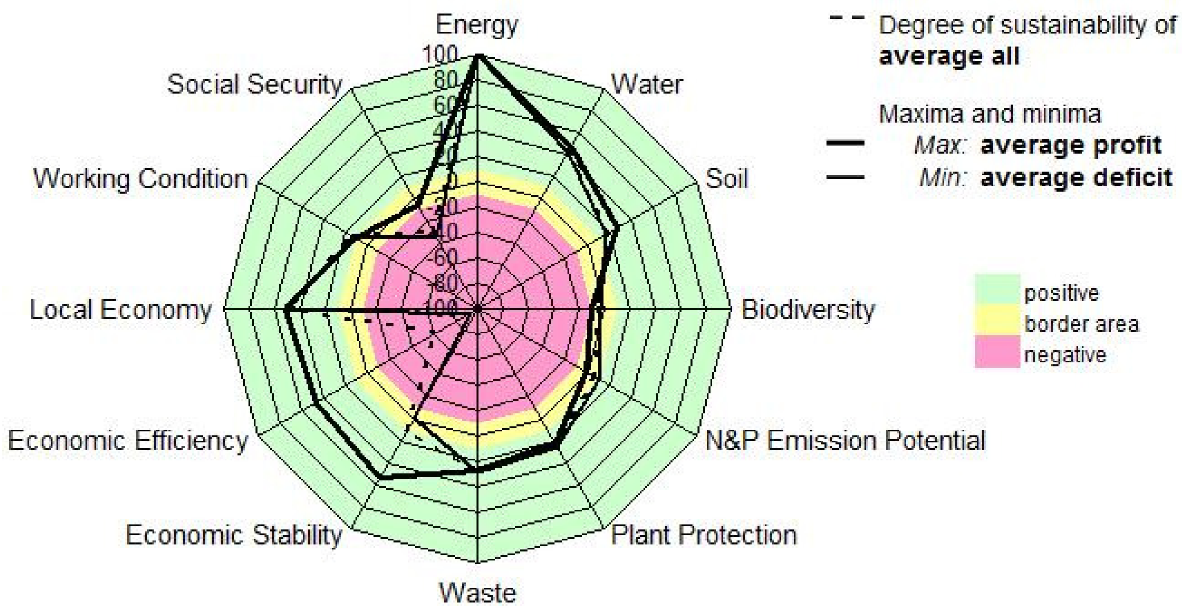


Fig.40: Average of the group making benefits (6 farmers) and the rest (23 farmers)

The group of farmers making a profit also achieves the best average of the 12 indicators. Figure 40 shows the three enhanced indicators of the economic stability, economic efficiency and social security of the groups doing profit and those making deficit. An obvious relation exists between economic efficiency, economic stability and social security.

The lack of incomes drive these indicators at a lower level, thus reasons of low incomes have to be pointed out. On the farmer's side, productivity is main factor that is related to fertility and the all set of agricultural good practices discussed in the chapter above. But farmers face the market that has to respond financially to their work. On this side, market does not pay the right value to the goods produced. Several reasons are undermining the correct exchange:

- merchants take lot margins,
- farmers are not well organised to defend their earnings,
- amounts produced are to much varying with the wet season,
- no diversification increases amounts and crashes the prices,
- external stabilisation miss or amplify variation phenomena,
- no industries or other groups manage the production that could stabilise quantities,
- no incentive work on this spiral of price lowering.

Further discussion is conducted in Chapter 5.4 about entry point 3: stabilising market prices.

4.12.3 Recommendations

All the economic efficiency indictors are related to income. An increase in income would ease the burden of agricultural expenses, and it would improve EE_SP2 and EE_SP3 if compared with assets and owner's equity. Should, however, earnings improve (EE_DP3 is currently low) and other parameters remain negative, then financial management must be re-organised. Other social aspects influence chances to create incomes, e.g. informal exchange through ceremonies instead of using the market places.

The same recommendations as those described in the section on economic stability are applicable to promote an increase in incomes. Further recommendations are also discussed in Chapter 5.4.

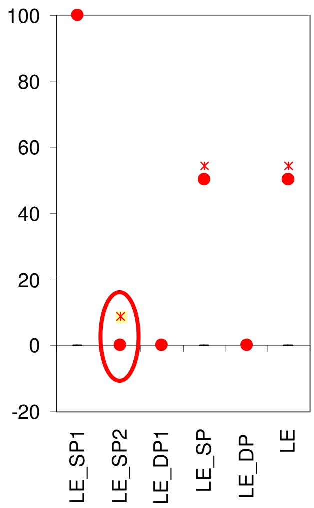
4.13 Local economy

This indicator assess the contribution of the farm to the local economy by considering the origin of workers, salaries and attractiveness in term of salaries paid and farm performance in relation to usable farm area. It is highly connected to the minimal and average regional wages, as explained in Chapter 4.2.3.

4.13.1 Results

The current situation in Ethiopia concerning wages per working person and regional wages is such that all farmers interviewed are outside the RISE range, resulting in no apparent variation. Figure 41 shows these blocked indicators. The indicator for share of regional working force and salaries is at maximum level because all workers are locals and salaries remain in the local economy (LE_SP1).

The second parameter concerning the lowest farm salaries compared to the regional average wage always remains at zero because children work as adults (same tasks but fewer hours) and farmers estimate them at a lower wage rate. As a result, all farms with children (93% have working children, two farms without) contain one or more low wages that lower this indicator for comparison to the regional average wage.



SP= State Parameter; DP= Driving Parameter; dash are means and dots are outsiders; circles show bad position of the indicator.

LE	Local economy indicator
LE_SP	Local economy (State parameter)
LE_SP1	Share of regional working forces and salaries
LE_SP2	Lowest salary on farm compared to the regional average income
LE_DP	Local economy (Driving parameter)
LE_DP1	Raw performance per arable ha and year

Fig.41: Local economy indicators of all PAs. Red dots are averages, without variations to show.

Raw performance is the sum of net sales, subsidies, external deliveries and variation in stocks. External deliveries are farm agricultural flows used to feed animals and humans and leave the boundary of the agricultural production system of RISE. High self sufficiency of farmers results in an increase in external deliveries and a reduction in sales. Raw performance is related to yields and market prices; both disadvantaging the farmer's performances per ha and per work force. Thus the indicator LE_DP1 firmly remains at zero.

4.13.2 Measuring self-sufficiency

Self sufficiency was calculated using the Financial Excel Tool, the sheet Product Flow and the sheet Ceremony. The Ceremony Excel sheet summarises the amount of household-consumed goods (A), wherever they come from. The Product Flow chart shows the produced amounts (B) that are remaining on farm after subtracting sales, loss of animals or crops and payment in nature. The result shows the potential consumption for self-sufficiency. All quantities involved are multiplied with their respective market prices. Both sums (A and B) are compared in percentage (self sufficiency rate) to reflect the extent to which home consumption is reducing potential sales. Only 24% of the farmers are below a rate of 100%, i.e. are consuming less than the amount produced. This means that farmers above the 100% level consume assets in terms of stock, fixed assets sold or use their savings. 38% of the farmers reduced their crop stocks, 34% their livestock and 14% had to reduce both. But there is no correlation between these changes in stocks and identified self sufficiency rate. This is probably due to lack of information, income from informal nets and unrecorded exchange and services, e.g. woman's work (sales of Talla[16], cotton spools etc.). This again is stressing the need for further investigations to better understand the way the farming families exploit resources.

[16] Local beer, home made.

4.14 Working conditions

Health- and equity aspects, work organisation, workforce satisfaction and security of basic human rights are the elements considered in the Working Conditions indicator. Due to the difficulties of getting information concerning a situation that does not reflect the reality of the farmers, the question on estimated wage difference for identical work was skipped (WC_DP4).

Wages are an estimation of how much the farmer would pay to a person doing the same work for each listed working force. Accommodation, food and energy consumption is then added as expenditures. In addition the assessment of working conditions was also shortened because of the inconvenience of asking about having a roof against rain and wind, a washroom or a place to store belongings. Employees share the same situation and are treated as family members. For further detail see Appendix 1 on Changes and Justifications, working conditions.

4.14.1 Results

As shown in Figure 42, the average of all working conditions indicators for all regions is approx. 10 points, except for Kuhar where it is slightly better. Figure 43 stresses some different parameters form up and lowland. For example, there is better access to medical care in the lowland and working time is organised differently: farmers situated in the lowland work fewer days (WC_SP4b) and more often compensate overtime than upland farmers (WC_SP4d). Holydays are dictated by the Orthodox Church that imposes approx. 70 holy days per year (eight days per month without the week-ends). Work is done on a regular basis during 52 weeks of the year. As a result, the indicator WC_SP4c is badly positioned. Whether the inclusion of number of working weeks as a factor of sustainability is relevant is uncertain due to the fact that it is related to culture and can vary globally and from region to region. Total working time and the management of labour intensive working periods seem more appropriate

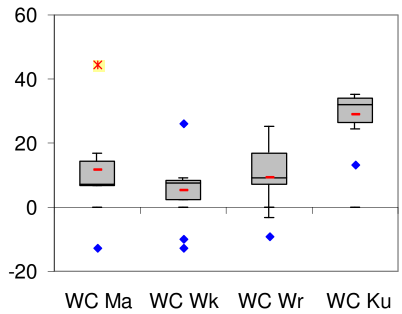
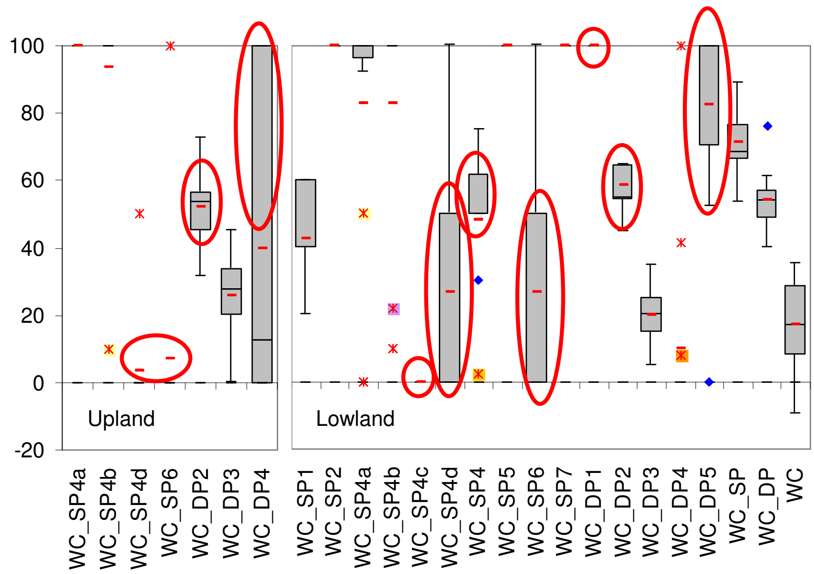


Fig.42: Working conditions indicator from the 4 PAs (Ma= Maynet; Wk= Worken; Wt= Woreta; Ku= Kuhar)



SP= State Parameter; DP= Driving Parameter; dash are means and dots are outsiders; circles show bad position of the indicator.

WC	Working conditions indicator
WC_SP	State parameter
WC_SP1	Medical care on site
WC_SP2	Provision of potable water
WC_SP3	Accommodation and sanitary
WC_SP4	Working hours
WC_SP4a	Working hours per week
WC_SP4b	Working days per week
WC_SP4c	Working weeks per year
WC_SP4d	Compensation of overtime
WC_SP5	Wage discrimination
WC_SP6	Not allowed child labour
WC_SP7	Forms of forced labour
WC_DP	Driving parameter
WC_DP1	Continuing education
WC_DP2	Encumbering work
WC_DP3	Working conditions
WC_DP4	Disparity of income
WC_DP5	Working time for reaching minimum wage

Fig.43: Working condition indicators of the upland (left) and the lowland (right).

for a culturally independent assessment of the working time.

There are more children working on farms doing the same work as the farmer (WC_SP6) in the up than in the lowland. Kuhar has the lowest rate of farmers with children that are not allowed to work. This explains their high position in Figure 43. There are no forms of forced labour as there is an oral contract that every individual can freely decide on whether to work or leave (WC_SP7).

There is a lack of further education (WC_DP1) for all regions concerned. The lowland seems to apply more complicated farming techniques, e.g. cross breeding and more permanent crops, but no time for continuing education was recorded as opposed to some in the upland.

Workloads (WC_DP2) are average, where the heaviest weights are mainly lifted by woman carrying water and men lifting grain sacs. Interviewed farmer don't especially complain about this (woman more), but there is no sequels to observe on human and children. Some instances were observed on markets where donkeys were used to carry heavy loads and were badly treated.

Working time necessary for reaching minimal wage levels varies widely due to huge differences in earnings for all farms (WC_DP5 same for both altitudes).

4.14.2 Healthcare and school

Some social aspects, e.g. medical care, accommodation, child labour, amongst others, are highly dependent on to the social context. Awareness can currently not be improved, because other forms of working conditions i.e. having a rescue plan, not employing children at a low age, providing accommodation to employees, etc. are unrealistic for them, do not belong to their culture and are to-date not part of their evolution. The Government successfully introduced schools to which children have good access. The Church and government pressure obliges them to attend, which is a way to improve knowledge and thinking capacity. School attendance, however, reduces agricultural labour input. With the help of the government, the NGOs introduced rural clinics to enable all farmers interviewed, as well as those from Soras that is situated a higher altitude, to get paramedical help within an hour.

In the Highlands out of towns, no children were observed that were begging, asking for help, being sick, injured, depressed or showing signs of malnutrition. Children carry out the same work as adult farmers but for shorter period. They start their working life at the age of between eight and ten years old. This, however, has little effect on their schooling. RISE assesses the situation of allowing child labour in such a way that it produces in these region and despite these observations a low indicator. It is doubtful whether sustainability would increase if working at such a young age was no longer practiced, as suggested by this parameter. Child labour in the studied area is a precious working force resource to help parents to get their vital goods and incomes. These young people would not appear to be over-exploited at a point that their life and future are badly affected.

4.14.3 Overtime compensation

Compensation of overtime seems to be a bad point but contradicts the measurement of average working time spent for agricultural purposes (see Table 11). The dry season and its low rhythm of agricultural activities automatically compensates the heavy working periods.

4.14.4 Working persons

Working hours and labour force distribution are important factors contributing to sustainability and farm efficiency. Here, work force[17] is therefore a key indicator for productivity. Figure 44 shows the distribution of work force per farm. Active persons are both parents and children aged 8 or more years that are able to carry out work like fetching water, weeding, harvesting, threshing, and ploughing etc. For both altitudes, the workforce shows the same total person average. The farmers in the lowland have more active family members and use employees. It means that there is presence of more inactive, young children in the upland.

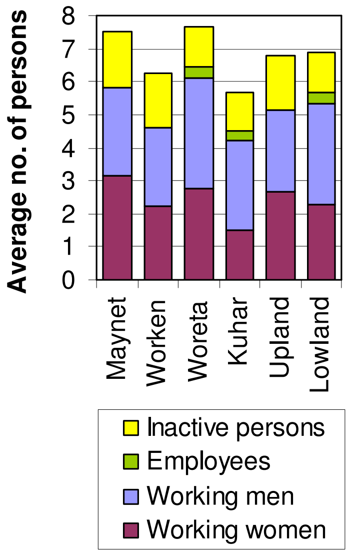


Fig.44: Nature of the work forces per PA and altitudes.

Figure 45 shows in more detail the distribution of active and inactive persons on farms per PA. Inactive persons are children that are too young to contribute to farm activities. There are no old people living at any of the farms interviewed. Farmers continue to farm for as long as they possible can and move into the nearest town when old age makes this impossible. There, they are reduced to begging as only means of survival. Inactive persons are a burden to the active family in terms of time required and consumption of the few resources available like water, food and household facilities.

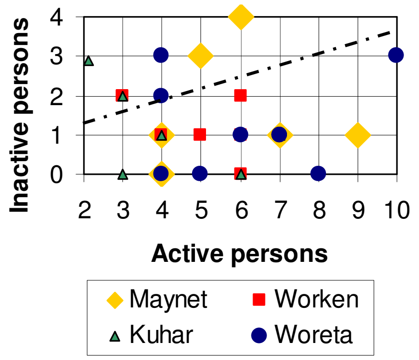


Fig.45: Active and inactive persons per PA. The dashed line proposes a limit of maximal rate for work force efficiency.

If work force availability ratio is defined as the ratio between inactive and active persons in a family, families are then linearly ranked from 60% to 100%. It means that per family 0% to 40% of all the work force is inactive. There is no correlation between operating incomes or net calculated loss/profit and this ratio. This tells that economic performances seem to not be directly related to this work force availability ratio.

The dashed line in Graph 45 shows a proposed limit for sustainable family planning or working force management and is a work force availability ratio of about 66.6% (⅔ active for ⅓ inactive)[18]. Values above this line, i.e. over 33.3% of inactive persons, will lower farm productivity in terms of income: time cannot be invested in farming activities, more products are used for own-consumption. Inactive persons might exist in this system, where children are growing up. Therefore, the dashed line cannot be positioned at zero like for an enterprise. For farms with higher production levels, the impact of inactive persons is more important regarding the reduction in working time of active persons than their food consumption. This work force availability ratio completes the RISE analysis and shows an aspect of the work force efficiency. Looking at this aspect, only the Worken PA has a good family structure and six families (20%) are loosing work forces for farm production due to the high number of persons in charge.

[17] *Work force* is for RISE a working person multiplied by a factor depending on its RISE category. The employed term of *working person* (wp) designate any *active person* and include also working children able to do adult works, without factor multiplication. The term work force in text is used in a general sense.
[18] 2/3 is an arbitrary number that should be justified or adapted by demographic studies.

4.14.5 Working time

Figure 46 shows the different average labour time. Adults work more than children; the resting time of children is used for school attendance. The children of the lowland would appear to attend school more frequently than those of upland. The adults situated in the lowland work 7% more, mainly due to the females investing 13% more labour. Females work more in general, up to 20% more in Kuhar, the PA with the highest apparent difference in working times compared to

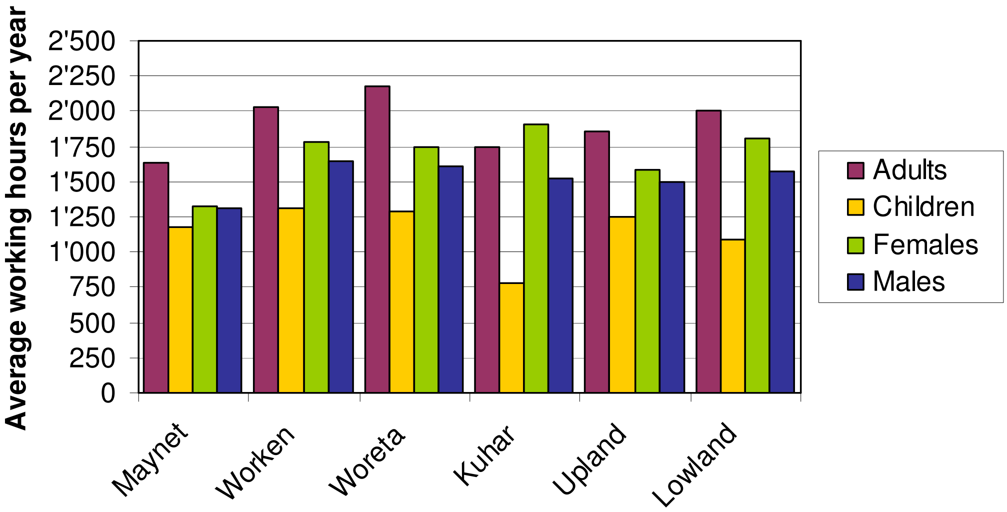


Fig.46: Average working hours per year for adults (females and males), children (females and males), females (adults and children) and males (adults and children) per PA.

other groups. Woreta invests more time for agricultural purposes, probably due to cross-breed cows and sale of the milk produced. All these working hours include household activities (mainly carried out by woman) that contribute indirectly to farm activities (e.g. woman provide food on far plots during planting, carry out weeding, harvesting and threshing activities, but also sometimes produce Talla that is sold near towns).

4.14.6 Work force performances

Table 11 shows the difference in actual labour for the farming systems to enable better comparison of work efficiencies. The income per active person situated in the lowland is approx. 64% higher than that for the upland. They also consume approx. 8.5% less. In the lowland 3.2 persons are sufficient to manage 1 ha of arable surface compared to 4.4 wp for the upland but these from upland work 23% less hours. Even though the total working time remains at approx. 3.7 days of 8h work per week for both altitudes, the lowland workforce shows a much higher productivity.

	wp/ha	Working hours/ arable ha	8h Days /week /wa	8h Days /week /wp	Operating Income /wp	Home consumption /wp
Upland	4.4	6'413	4.47	3.61	409	2'954
Lowland	3.2	4'973	4.83	3.79	1'157	2'702

Table 11: Some workforce indicators. (wp = working person or all active person; wa = working adult; currency in Birr)

This efficiency is, however, also related to several exogenous factors like, for example, soil fertility, slope, market access and prices, thus inhibiting the assessment of relations between workforce efficiencies and human capacity or external factors.

4.14.7 Recommendation

Taking into account the hardness of the rigid context and comparing it with the possibilities available to alleviate working conditions, it is quite difficult to suggest any direct recommendations. Low working efficiencies in the upland are a complex interrelationship in need of further analyses. The low number of working hours is a result of religious and cultural traditions. The resulting resting periods appear to be sufficient to allow recovery of body strength. In addition, donkeys are already used to reduce human workloads. Moreover, child labour appears to not have a detrimental effect on children's schooling or their health. Health centres are usually within one hour's reached and make it unnecessary for families to stock more complex medical material at home in case of accidents. Health problems are mainly the result of poor water quality. This indicator, however, does not assess this factor, despite its obvious effect on working conditions. 15% of the interviewed families from the upland were affected by health problems that prevented work of some of the farm workforce for several days or months. The rate for the lowland amounts to 6.5% due to access to filtered water (well, hand pumps and tap water, see Fig. 16).

It would appear that working conditions are a consequence of the current system or, in other words, they are driven by external factors which are mainly related to water quality (health, inactive sick persons) and social investments for ceremonies (time spent on agricultural purposes).

4.15 Social security

The working condition indicator is looking at basic human rights, health and equity aspects and work satisfaction. This domain of RISE had to be adapted to the context, see Appendix 1 on Changes and Justifications. For example, social security (SS_SP1) is looking at 5 ways of assuring against social problems. The original RISE program assesses old-age pension, unemployment, health, accident and disability insurances whereby formal insurances as well as informal safety nets are assessed regarding their adequacy. The new labels used in the field are old-age pension, inability to feed the family, accident or health problems, long-term inability to work, any serious conflicts, and represent the overall range of potential problems that should be protected by insurance.

4.15.1 Results

The social security indicator shown in Figure 47 is negative for all PAs assessed and is marginally better for Maynet. Tendencies for all show a similar pattern and are presented in more detail in Figure 48. The social security indicator SS_SP1 shows that the situation is not sustainable. Moreover, the means of subsistence (SS_SP2) indicator reveals that the minimum salary is not sufficient to cover the living cost of a "normal" family.

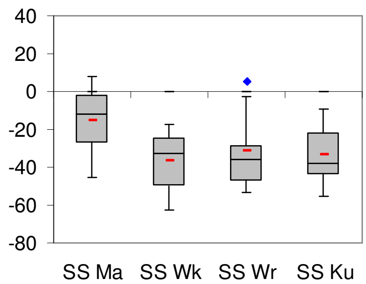


Fig.47: Social security indicator from the 4 PAs (Ma= Maynet; Wk= Worken; Wt= Woreta; Ku= Kuhar)

Farm succession plan has a negative effect (SS_DP2), farmers do not conscientiously organise the continuation of farming.

Most of them said that one of the youngest sons will take over once they have reached old-age. This it is not a problem in itself but are difficult conditions when several sons want the same piece of land and have the legal right to it. This factor of family growth has the effect to divide plots, push farmers to find new farm land to increase their income resources and creates conflict in instances where several sons want soil surface that is not available.

The potentially payable salary is related to income and minimum gross wages of the region. The bad position of this indicator (SS_DP1) shows that the corrected operating income[19] is small compared to the number of workforce and their salaries. This increases the risk of having no assured regular wages.

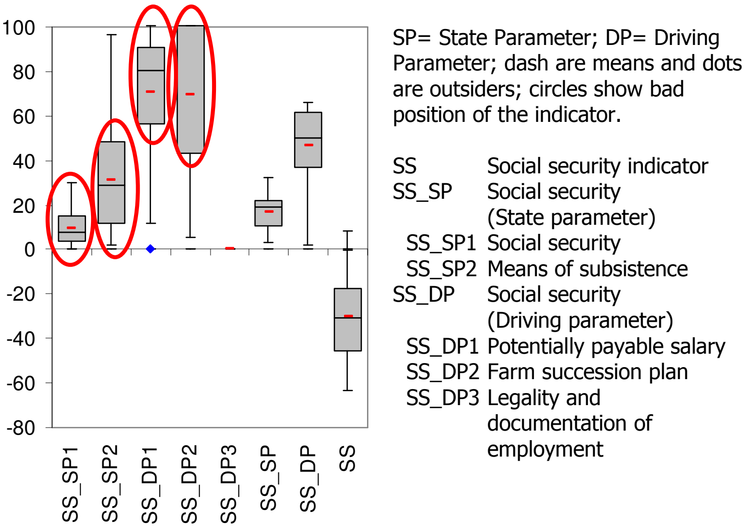


Fig.48: Social security indicators of all PAs.

4.15.2 Safety nets

Farmers are not obliged to make provisions or contract insurances. Their only safety is to use grain- and live-stock to pay for necessary services when problems arise, if available. The only available service is basic healthcare from health centres that can be reached within an hour's walk. In case of climatic disaster, accident or conflict, farmers have to organise themselves through informal social networks. The RISE questionnaire assesses this in general by asking if the system (any kind) used is adequate or not. Most answers were negative, except for their method of solving conflict that appears to satisfy their needs. Any social network is insufficient if safety and care needs of the population are higher than the sum of available resources for satisfying these needs, which seems to be the case in the studied region.

4.15.3 Gender

To enable the development of a solution for improving social security, more detailed research is required to determine the actual functioning of the informal safety network. First observations show that their system is patriarchal. Wives, however, remain in contact with their own family. The relationship between genders is mostly balanced. Here, males have control over grain harvest and cattle, women over small livestock and household. Both retain the money from their market sales and share it if required. Ceremonies are used to consolidate the social network. It is not known if this network is based on cultural origins, politics or religion. Apart from the 8 days of weekend per month, farmers spend in average six days for ceremonies per months.

4.15.4 Employment

For the 5 farmers having employees (F20, F25, F27, F29, F30), all from the lowland, questionnaires and discussion showed that relation between employer and employee is based on friendship. Both have the same access to accommodation, and each looks for his own insurances (social network, money or assets). If an employee is injured during work, help that

[19] Operating income without interests on debts, lease and rent

could affect the farmer's resources (time, money or assets) is dependent on the goodwill of the farmer. Farmers have the tendency to lower the value of employees by estimating a lower wage for them than for himself, even if employees work as much as the wife.

There is a governmental employment framework in place that applies to companies, where governmental taxes are higher. Employment is a way of increasing workforce efficiency when child labour is insufficient to satisfy farm needs. Farmers having employees have a higher arable surface (average of 2.2 ha compared to 1.5 ha for farmers without employees) and more animals (average of 8.8 TLU compared to 3.5 TLU). 3 of the 5 are milk producers who sell their product. Farmers with employees create 28% more income per workforce than other farmers from the lowland.

Farmers and employees	Arable land, ha	Tropical Livestock Unit, TLU	Incomes per WP	Total agricultural expenses	Total assets	Operating income	Calc. net profit/ loss	Available cash	total working forces	Working force efficiency in %
with (5)	2.2	8.8	1'420	26'449	95'122	8'376	-21'824	6'840	6.8	92.9
without (9)	1.5	3.5	1'029	19'870	46'193	11'952	-12'440	3'410	4.6	76.7
Difference is	29%	60%	28%	25%	51%	-43%	43%	50%	32%	16%

Table 12: Main differences in some numbers between farmers with and without employees in the lowland.

Table 12 shows some typical numbers. Farmers with employees have 51% more total assets, 25% more expenses and 43% more calculated net losses even if workforce efficiency is 16% better. Having employees is probably dependent on farm size and workforce efficiency. It is a step further in the evolution of the farming system. The financial mixed results of these five farmers indicate that this is still not an entry point for improving overall productivity. However, operating incomes with better workforce efficiency can be observed. They have the same number of working persons per arable land surface (3.2 wp/ha) as the others but have more arable land and TLU. These reasons seam to be related to management quality, but further analysis should be done here.

4.15.5 Recommendations

It is certain that increasing general productivity and quality would affect crops and livestock quantities and their financial values. This would support to the actual insurance system farmers use. Social studies can indicate ways to create new social pathways to increase the exchanges of resources in case of problems.

Employment at farm level makes a significant difference in the management of resources and further analysis should be carried out to detect the reason why farmers using employees are unable to make more income. This base should enable some recommendations concerning this subject. Further literature studies on land tenancy and farm succession rights should be done to understand the relationship between land division, migration and workforce presence and their impact on farming efficiency.

4.16 Conclusion

Despite some imprecise data, RISE was able to efficiently pinpoint the unsustainable practices. Proposed recommendations are deducted form the indicator level and do not take into account the overall context. Practical, obvious solutions were discussed with farmers and different actors on site. Most of them knew about composting, the power of diversity, measures to combat erosion, no tillage, intercropping etc. To overcome this general blockage of implementing simple and obvious solutions as mentioned as recommendations in the previews chapters, overall conditions must also be taken into consideration. Farmers adhere to their traditional practices for a good reason. Assessing these factors goes beyond the RISE analysis. Several informal interviews allowed a brief assessment of these broader driving forces:

Some main social or psychological principles could be detected during these interviews that could indicate that the Ethiopian mentality also plays an important role:

- Get maximum benefit from minimum effort;
- Do not deviate from social trends (which are mainly driven by religion) to protect your social advantages;
- Imagination is limited to piecing together actual and tangible reality;
- Actual reality takes priority over any mental concept or future projects and possible changes;
- Human justification based on day-to-day needs have priority over ecological reasons.

In summary, local people are sensitive to the amount of labour required to implement change, the extent to which the implementation makes them different to others, level of difficulties of change and short-term advantages brought about by change. Any active approach involving the farmers or farming equipment must take these factors into account to have a chance to be well accepted, attract the lowest possible amount of resistance and to increase the probability of successful implementation.

Ways to improve the RISE tool to adequately reflect Ethiopian circumstances are listed in Appendix 1, "Changes and Justifications". The next Chapters will introduce main entry points and secondary points to support possible change.

5. Options to harmonize livestock and water management practices

Three entry points are found enabling to unblock the situation: *gathering scattered plots*, *managing free grazing areas* and *stabilizing market prices*. Five other secondary points are identified and developed in Chapter 5.5.

5.2 Entry point 1: gathering scattered plots

5.2.1 Justification

Drawings of each farm plots' layout with surfaces and distances provided an insight in poor optimising of the land tenure, which creates huge losses of labour and favours easy theft and conflicts. The current system of land tenure is a source of discouragement for conserving the land. Several types of land tenure coexisted till the Derg regime proclaimed the total control of all kinds of surface in 1975. Farmers were given permanent land-use rights to areas based upon family size. No family was allowed to exploit more than 10 ha and no part of the land could be sold, exchanged, mortgaged, rented or leased. Every male above 18 years old was entitled to have farmland, and land use rights could be inherited. Land allocation was the task of the Peasant Association officials, and frequent redistribution was carried-out to accommodate the growing population. This was a first step towards, but subsequent policies and strategies led to further land fragmentation. The fragmentation resulted even in cases where farmers held plots sizes below minimal subsistence requirement. Even after the new constitution of the Federal Democratic Republic Government (FDRG) in 1992, land is still a collective property of the Ethiopian people and not subject to buying and selling deals. Exchanging of plots is allowed and land ownership is quite secured as long as the farmer exploit his plots and the government does not need them for any constructions. Farmers possess an official booklet recording all their plots.

In addition to the increasing demand resulting from a growing population the tradition of giving a piece of land to the son contributed to a dramatic land fragmentation, which is creating land pressure, marginal areas disappearance, cultivation intensification, pathway reduction, decrease of biodiversity and appearance of new conflicts. Today farmers have to walk far distances to reach the plots they want to cultivate. 60 to 100% of the arable surface is found detached from the household. In this study only 3 farmers (11% of the farmers' sample of 27), situated in the lowland, have gathered their plots below a rate of 20 to 30% of disconnected arable surface. 2 of them belong to the group of farmers having the most diversification in crops. However, no correlation is found between this good percentage and operating incomes or calculated net profit/loss (they do losses). As illustrated in table 13, 43% of labour is usually spent on the way to plots, whereas those farmers with gathered plots walk 23% less. Having gathered plots allows sparing an average of 26 km/ha/year of walk for other purposes.

	Distance walked to go on plots	Total walk for the work on plots (Plots' labour)	Part of labour spent on the way to plots	Plots' labour per arable area	Arable land	Perma-nent crops	Perccentage of scaterred surface
	km	km	%	km/ha	ha	ha	%
Average 80-100% (15)	86.4	197.4	43.6	134.4	1.536	0.093	89.0
Average 60-80% (9)	66.7	153.7	43.1	125.5	1.335	0.019	70.0
Average 20-30% (3)	41.4	202.8	20.3	99.8	1.962	0.620	25.1

Table 13: Labour parameters of 3 groups of farmers (20-30% of scattered area, 60 to 80% and 80 to 100%).

No farmer was found to have between 30 and 60% of scattered surface, which means that there is a clear strategy to exchange plots in order to get this management beneficial configuration. The three farmers having good plots' layout were able to list advantages of having such a plot configuration by themselves: less labour, more time to reinvest in agricultural purposes, better surveillance and thus the possibility to invest in permanent crops and divers vegetal assets without fearing thefts, quicker reaction when crop pests start, shorter and stronger fence, less dung lost on the way, and a higher motivation. Looking at table 13, these 3 farmers reinvested time in new labour by adding arable surfaces. They also invested in permanent crops that increase diversity, but not in annual crops or richer rotation. Bigger stony fences were observed around their land.

During feedbacks farmers agreed to these advantages. Disadvantages of gathered plots were also listed. Among them the potential bigger impact of local climatic disaster and the possible family discordance to exchange plots. Climatic aspects can be counterbalanced by a higher diversity in trees protecting from small tornados, tempering quick temperature changes. Improving rotation can reduce potential pests. Gathering plots is limited by the necessity to keep plots of high fertility or connected to irrigation systems. Thus the rate of 20 to 30% of scattered plots seems to be a good solution.

The feedback given in Maynet showed this aspect as new to farmers, but not out of subject. Worken PA was already aware of the potential of adjacent plots and is starting to exchange. The lowland areas are in advance and Kuhar as well as Woreta PA were not surprised hearing about this improvement. Kuhar has developed this strategy quite far but gives evidence about familial problems of inheritance and legal possibilities, but this was not totally confirmed by ILRI staff. There is no legal barrier to exchange; in general, the limiting factors are awareness of the interlocutors (potential plots' exchangers) and complication of the net created by the ownership of scattered plots.

5.2.2 Propositions

Because farmers know exactly which plot is to exchange regarding to its productivity and the effort the farmer have to do to increase the poor fertility, it is meaningful to support them in their own process to exchange. To overcome limitation of this natural process:

1. administration should support farmers' process to exchange in a complex situation of ownership. It could be extension agents listing the interest of concerned farmers and playing the intermediate to negotiate;
2. awareness of people has to be initiated on the real value of labour compared to all other factors like fertility, type of possible crop to plant, diversity and market opportunities;
3. techniques to increase fertility of gained plots should attend the process from beginning.

No cadastral plan exists which is able to manage official pathways and access to divers resources. More conflicts are rising due to the increasing land pressure and the disappearance of pathways. Large plains of fertile land are found without any houses (see photo 1 above), giving an impression of huge effort that has to be made to go to these fields and to bring harvests back home. This is due to the high value of fertility, a more important factor of choice to farmers than labour. However, this mentality originating from the reallocation period thirty years ago is discussed more and more today. The three farmers with gathered plots are in advance regarding their time. The project of supporting farmers in gathering plots should not be seen as a new reallocation process which is a sensitive topic. It should support the *natural* process by creating awareness, using participative sessions and encourage exchange by administrative support and teaching fertility recovery techniques.

5.2.3 Impacts of less labour

A scheme of the interrelations and impacts on techniques of having scattered plot is presented in appendix 2, panel 1. More labour affects various technologies and those have an influence on the efficiency of the farmer to produce more with the same soil and water resources. Better implementation of simple technologies can affect soil fertility (animals are more present on the farm surface, less dung is harvested from others or lost on the way). Thus yields, plant protection and erosion depletion can be increased. Keeping animals close to the house allows a better control of their growth, less disease by contacting other animals or by passing through hazardous places, and an increase of milk yield as the animal looses less energy by walking each day. Residues can be better valuated by the farmers herd only, but better management is expected from the farmer to control the fodder production to support continuous and optimal animal growth. Increased cultivation of permanent crops allows household food and market sales diversification. Furthermore new assets could be grown as fodder trees, medicinal plants or soap bushes.

Appendix 5 presents in details the impacts of this proposition on all bad parameters. This improvement of the farm layout has a positive impact on all indicators, if the farmer applies appropriate techniques at the same time.

5.3 Entry point 2: managing free grazing areas

5.3.1 Justification

Communal free grazing areas are free of charge and any animal can access these overgrazed surfaces. Even on entirely flat land, large gullies give evidence of the destroyed soil structure and lack of roots keeping soil particles together. Overgrazing is a negative balance where animal pressure is higher than grass production of the surface. This balance changes with rainfalls, temperature, fodder productivity and animal presence (herd management). The only management found was for some restricted communal grazing area, only open for ploughing oxen at specific times. Even on these surfaces, dry grass stands were found at the end of the dry season. This grass resource is wasted: green harvested grass contains much more nutrients than yellow old grass. It was heard that farmers consider hay as not nourishing because of its lightness. However, hay harvest was found to be made by two or three farmers on their own grazing areas.

These observations show that management can be organised to discipline people around such a resource. It tells also that hay harvest is a known and working technology, but not yet widely accepted. Beside gullies, the second future of a grazing area, as explained in detail on the panel

2 in appendix 3, is the invasion of prickle weeds named *Hygrophila auriculata*. Some IPMS projects (Improving Productivity and Market Success of the Ethiopian Farmers) are organising people to harvest and burn these plants to recover grazing surfaces.

With or without gullies, overgrazed areas loose a lot of soil and fertility by run-off and thus fatten rivers with polluting substances. Estimation gives 40t/ha (~4mm) of lost soil per year. This amount affects water quality downstream (see Chapter 4.5.3.1) and clogs irrigation systems of Sudan.

5.3.2 Propositions

Two propositions are made to regain the productivity of these important resources. The first consists of *redistributing the free grazing areas* to farmers with the impact to shift the total absence of responsibility to personal responsibility. A farmer will have to manage this resource to feed his herd adequately, additionally he will have more constraints (no more free areas) to resize his herd and will also take himself measures against eventual erosion. One farmer spends 20% of the total grazing time[20] on communal areas and produces hay from its private surfaces. Two other farmers spend 0 and 20% of their grazing time on communal surfaces while the rest uses communal areas from 45% up to 95%. Six farmers (21.4%), mainly situated in the lowland (only one in the upland), do hay harvest or have pasture in rotation. This study was not able to look at the efficiency of using this technique.

The second proposition is to *pay for the right to graze on the free grazing areas*. An association could be founded, which collects a tax. The money should be used for managing the resource by constructing necessary infrastructure and organising sustainable exploitation, e.g.: building fences, weeding, surveillance, park rotation, pathways definition, irrigation, swamps clearance, hedge plantation, fodder selection, trials, anti-erosion measures, etc. Overgrazing can be managed by adjusting the stocking rate according to the fodder production to find and keep optimal pressure. Too high pressure forces animals to consume sully uneaten grass which decreases quality and livestock performance. Too little pressure leaves more uneaten grass and the resource stays unexploited till it is harvested for hay storage.

Both propositions need support of the government to give the process a legal frame. GTZ has some projects on gully remediation that implement group dynamics to fix rules and thus can protect newly planted zones from grazing and theft. This is an important point to make any results of implemented techniques sustainable: organising the society or set a frame of allowed behaviours for all around the concerned resource. It could be achieved by applying a participatory approach and receiving governmental administrative support to approve rules and lay the foundation of a legal framework for efficient social impact.

CARE has successfully realised the rehabilitation of a part of a free grazing area with several farmers. In this project, a group of farmers fenced a part of the free grazing area which they used. They ploughed it and grew improved fodder species. Rules were designed to manage the grazing pressure according to the grass growth. Small taxes between farmers could serve to manage in a fair manner access of each for livestock grazing and hay harvesting. Limitation explained by CARE was the difficulty to scale up this management due to personal striving of the majority for free access to the resource, even if this resource is in reality already extinguished. This argument needs to be deeper discussed with a social approach.

[20] Total time spent by the animals on private and communal grazing areas

5.3.3 Impacts on livestock productivity

The panel 2 (appendix 3) on the impacts of the actual management of free grazing areas illustrates the cascade of ecological events above and below the soil surface. By keeping grass on a too short level, water will pass faster through the system either due to an increased run-off or due to insufficient structured soil and humus absence, making the soil unable to store infiltrated water. Soil moisture periods are shortened. Roots decrease proportionally with the cutting height. Exposed soil increases evaporation and accelerates the drought process. In the meantime less grass is available for livestock. The success of a good livestock productivity is highly correlated to fodder productivity, which is correlated to herd sizing and grazing areas management.

Table 14 shows the time spent in average on grazing areas. The time spent on a grazing area ranges from 3.7 h/d to 12h/d during the all year. Half of the herds spend the same time on free grazing areas during dry and rainy seasons. The rest use it less in the dry period. Upland farmers use free communal areas more extensively than lowland farmers (28.5% of table 14). The less the free grazing area is used the more a farmer has to feed the herd himself using his private grazing surfaces and residues. Fodder as a crop is not produced yet, but one farmer in the lowland is planning to produce fodder for his crossbred cows due to missing energetic feed supply.

	Average of those using grazing surface				
	private, in h/y	communal in h/y	total hours per days	using only communal	using only private
Upland (14)	1'258	1'851	7.2	35.7%	7.0%
Lowland (14)	1'053	2'289	8.3	28.5%	0%

Table 14: Frequentation of grazing areas in up- and lowland.

5.3.4 Irrigation and water management

The region faces three patterns of rain: a dry, a slightly wet and a real rainy season where 88% of the precipitation falls between June and September. Climatic variations sometimes cancel the little rainy season as it happened this year 2008. Different strategies have to be mixed to temperate this variation on field and should try to supply crops with continuous water. The problem during the rainy season is the run-off while in dry season it is the lack of water for crops. Human and animal find water all year round with continuous decrease of quality during dry season recovered in rainy season.

From these heavy rains, vegetation, crop and fodder will use as much as they need; the rest is subject to run-off and infiltration. The infiltrated part fills up the soil pores, pours the underground water, elevates the water table, lengthens the residual soil moisture period and consequently increases the growing rate of natural vegetation recovery. Run-off is lost and takes fertility away while fatten rivers are clogging downstream systems.

With increasing infiltration the soil can retain more water to extend the moisture period after rains stop in October. This is possible by covering more surfaces with vegetation during the year. Any advised cropping techniques must include this aspect of keeping vegetal cover as long as possible to retain precipitation, to reduce erosion and to valuate this water into vegetation. But also during the dry season vegetation cover is important to valuate soil evaporation into useful plants (fodder, commercial trees,…). Cover can be provided by the shadow of the trees and hedges, fallow or pasture in rotation. Then the soil is able to play the role of sponge (pores and humus effect) by releasing pumped water after a rainy period.

Irrigation is not necessary during the rainy period of four months; the whole region benefits of the optimal amount of water provided. Irrigation makes sense after the residual soil moisture period ends three to four weeks after the rainy period, as it enables to extend the moisture period till far in the dry period. Water originating from rivers decreases as quick as the soil emptied its pores, as well as water from irrigation systems. Soil pores management guaranty the best water supply to these systems and is in upstream dependent to soil cover and fertility (humus as a sponge). Conflicts exist to access scarce water from rivers during the depletion period in the middle to the end of the dry period. This pressure leads to mismanagement of the resource: unfair distribution occurs and as soon as water is available a thirsty farmer will flood his field for several days.

Increasing water productivity of fodder by selecting and implementing new species is a way to better valuate the water which is passing through the ecosystem during the wet period. To be powerful, this effort must be implemented in regions where:

- irrigation is well developed, and fair distribution is already organised;
- covering soil is already a common practice in the cropping techniques, mainly done above the irrigation systems in the same watershed.

A lack of water or a short moisture period will reduce the chance of getting the best advantage out of improved fodder species.

Implementing irrigation systems cannot be seen separate from a social organisation. This includes both the establishment of a government accepted association which introduces rules and project planning, but also the availability of financial resources and technical support provided by NGOs. Improved yields and a good social organisation which is able to drain money (or any mean of exchange) for maintaining and polishing the system will guarantee its sustainability.

Storing water of the heavy rainy period for prolongation of the moisture period is an complement to cover soil with vegetation. Both strategies have the same basic effect to store water, but storage facilities at middle and big scale are not to be advised. Silt will fill the storing volume within a few years. Furthermore it requires surfaces and cannot be associated to biodiversity improvement as a better soil cover strategy can be. Therefore this approach can be advised for a small scale only, to valuate inevitable run-off on a household area. Several small infrastructures can drain this water in ponds or redirect it in downstream fields.

Storage of water collected from iron sheet roofs in plastic reservoirs is also a possibility to serve near fields and to instigate the cropping of for example vegetables during transition period between dry and wet season.

The approach to improve water management faces the basic observation of people that enough rain falls and that water for home and livestock consumption still remains available during the whole year. Convincing the society to save the resource from run-off and to organise irrigation infrastructure is therefore difficult as it is not seen as a priority by the people. Thus it is not proposed as a principal entry point but as secondary one.

Implementing this second point would affect RISE indicators on water, soil and biodiversity, if these surfaces would be part of the RISE boundaries. Indirectly all indicators related to the incomes would be positively affected, as illustrated in detail in appendix 5.

5.4 Entry point 3: stabilising market prices

5.4.1 Justification

The market is the place for exchanges between producer, intermediates and consumers. There the farmer's work is valuated by the society through the demand and related prices. The following observations were done on three markets (Woreta for Woreta and Kuhar PAs, Debra Tabor for Worken and Gasay for Maynet) near the PA's and through informal interviews on the Gumara market at the crossing between the main road and the Gumara River:

- Low product diversity on the markets and mass production (e.g. tomato, onion, potato,…) both at same time increase the variation of prices and sink the real value. Diversity is found in the grain sector itself (cereals, peas, beans), not in vegetables and fruits. Even when huge amounts are available at a low price, no infrastructure or industry is there to take advantage of this opportunity for processing or exporting. Big governmental grain storages are seen near the main road in Woreta, and some speaks about prices speculation strategies or a tool to drive prices of basic commodities.
- Produced quality is middle to low; this creates losses and lowers the prices. Quality is a criterion to sell more from same harvest, but a balance has to be kept between the additional work which is necessary to achieve this quality and the chance to sell the expected quantity.
- Low prices demotivate farmers. Two strategies can be undertaken: a farmer can either diversify and find new niches or he can focus on cash crops to avoid risks. Diversifying needs knowledge and boldness to assume related risks. Regarding the actual low diversification, farmers opt here for cash crops and thereby they amplify the problem of low prices.
- Innovation cannot start due to mass behaviour. Here social science should help to determine factors which could contribute to take farmers on the way to market independency and innovation. Actually, risk calculation together with low input or availability of resources leads to the poor range of crops that is found on the markets today. No incentives are organised. Lack of knowledge worsens risk calculation. However, history tells that introducing new products had success in the past; e.g. rice implantation in flooded areas of the lake as well as improved onion species, both are cash crops today.
- Merchants take too high margins and create commercial pressure on the farmers which are no merchants. These markets are completely free of rules and regulations. Isolated farmers have few chances to valorise their harvest adequately regarding to the merchants and intermediates specialised to maximize benefits. Some informal associations exist but have little power to drive market prices.
- The farmers which are able to produce milk usually have good incomes. Table 15 presents the general economic performance of three groups of farmers, representing farmers not producing milk, farmers producing but not selling milk, and farmers selling milk from cross bred cows (all in Woreta). None of the farmers in Worken produces milk, even not for home consumption. Operating incomes are better for those who are selling milk but they still not achieve a profit. Grain stock and livestock evolve during the year in a complete different direction between the three groups of table 15, showing that different strategies were conducted by these groups of producers during the year.

Produced milk per year	Sold milk	Operating income	Calc. net profit/ loss	Variation of grain stocks value during a year	Variation of animals value during a year
in litres		in Birr			

Average not producers (13)	0	0	7'324	-16'003	1'584	1'294
Average not sellors (9)	420	0	11'259	-5'651	1'844	3'561
Average milk sellers (6)	2'115	1'253	15'102	-12'684	7'033	-4'233

Table 15: Groups of farmers producing and selling milk and some economical indicators.

The downwards spiral of this situation is illustrated in appendix 4, panel 3 on impacts of the market situation on farming management. The varying amounts per product observed during the year is accompanied with high price variation. Farmers make fewer margins during periods of low pricing and lose potential incomes to reinvest in their enterprise. This leads them to focus on cash crops and not to follow any risky strategy, which again lowers the diversity and amplifies the problem of product overflow. This kind of yearly or seasonally rhythm of producing same products in big amounts is depleting fertility and increasing disease susceptibility of these monocultures. This last aspect of lowering fertility by monocultures is a long term negative impact on prices, whereas yearly variation of amounts and thus prices has a more rapid influence on the all system.

5.4.2 Propositions

Observation showed that farmers are passive regarding to their situation, unable to conduct themselves market tendencies, to take initiatives or to produce in some cases more than needed. Innovative farmers exists and have some personal success but have no impact on the overall behaviour. Some informal associations are existing, but they are not able to drive the market and the farmers' choices. This shows the need to look at the situation on a broader scale.

Three propositions to stabilise prices are presented (in the present study). Their objectives are to give fair prices to the farmers. The first proposition is to create *markets with controlled prices for local exchanges*. The Kuhar Multipurpose Farmer Cooperative is an organisation supported by the government, which supplies farmers with tools and fertilizers. The cooperative aims to implement this project of a price controlled market. Farmers will have the opportunity to sell at a better price than those on the free markets, interlocutors will diversify. Both the resulting economic impacts and the necessary functional framework need further investigations.

A second proposition is the *implementation of relationships between the industry and farmers* through professional enterprises, which are able to start new productions, to follow farmers technically from start till harvest, and to buy farmers' products at agreed prices. Supported by the industry with fair commitment of both, farmers can rely on more stable partners to organise their own progress. The government should support this process by defining a necessary and sustainable framework and it should guarantee more security in land tenure. Further, the government should adapt educational programs to produce professionals, which are able to take over the huge agro-commercial opportunities present here.

The third proposition is *the promotion of milk production and its value chain*. The Woreta Milk Farmer Cooperative was created with support of GTZ and works well. The enterprise is limited by marketing and conservation techniques to transform surplus of milk into cheese. So the cooperative does some milk wastage but still makes some benefit. The milk value chain increases food diversity, spreads healthy products and asks for more professionalism of the associated farmers. Milk production requires an increase of knowledge and a stimulation of commitment – two human factors which are necessary to improve the productivity of a resource.

It appears in table 15 that those milk producers earns more then the other but have also high calculated net losses. Here it can be understood that their management is not well organised to lower losses and internal costs of keeping their crossbred cows productive and healthy. It stresses probably the incomplete technical support from extension agents and also market availability of adequate fodder and concentrates. Anyway, promoting milk production can be a good stimulation to improve the all value chain (from fodder to cheese production) because the potential demand is present and thus can support its development.

5.4.3 Links to ILRI's framework

Stability of market prices is related to water and livestock productivity in terms of economical value, not in terms of a natural product. The market place is the last step to valuate the entire process from organising and producing till harvesting and processing. As soon as productivity is measured in monetary units, market prices will definitely influence this concept.

Implementing this third point would have less direct impacts on the RISE indicators except for those related to incomes (economic stability, economic efficiency and local economy as the working conditions), as presented in Appendix 5.

5.5 Overview of the proposed solutions (8 entry points)

These three first entry points are acting at a high level and involve participation of the government. These solutions alone are not sufficient to release the situation of blockages and must be accompanied by more specific actions to increase water and livestock productivities efficiently at a practical level. Table 16 summarise impacts of the three entry points on the two main objectives of ILRI, namely an increase of both water and livestock productivity. In order to meet these objectives and regarding the key techniques of improvement for each bad parameter listed in Appendix 5 (last column right), five other entry points are identified as secondary necessary actions.

<table>
<tr><th colspan="2">ILRI's objectives:</th></tr>
<tr><th>To increase crop/fodder water productivity</th><th>To increase livestock productivity</th></tr>
<tr><td colspan="2">Impacts of the main entry points:</td></tr>
<tr><td colspan="2">Entry point 1: Gathered plots (See appendix 2)</td></tr>
<tr><td>Enhanced labour efficiency accompanied by good applied practices will increase fertility with the same amount of water and thus will improve crop/fodder water productivity.</td><td>Facilitated livestock management, less walks and a better herd control accompanied by good feeding practices will improve livestock productivity</td></tr>
<tr><td colspan="2">Entry point 2: Free grazing area management (See appendix 3)</td></tr>
<tr><td>A group managed grazing area is integrating a better use of the fodder resource and, together with a good grazing pressure management, it leads to an improved fodder water productivity</td><td>Saved and improved large grazing surfaces will provide livestock with access to more fodder quantity and quality for a better general productivity.</td></tr>
<tr><td colspan="2">Entry point 3: Stabilised prices (See appendix 4)</td></tr>
<tr><td colspan="2">Good and stable prices will play a role in the calculation of the benefits and thus increase water and livestock productivity.</td></tr>
<tr><td colspan="2">Secondary necessary entry points to meet objectives and to complement entry points 1 to 3:</td></tr>
<tr><td>Entry point 4:
Water storage, irrigation systems and association for management must be implemented to save water quality, to reduce water shortage in dry periods and to distribute the water resource to crop/fodder and livestock producers in a fair way.</td><td>Entry point 6:
Fodder production (on site, by-products, residues, hay, silage, storage,…) has to be well introduced in the farm practices.</td></tr>
<tr><td>Entry point 5:
Change in cultivation techniques (cover, weed control, no tillage,…) and rotation habits (intercropping, diversification,…) will increase soil cover and thereby lower erosion and fertility losses.</td><td>Entry point 7:
Herd management (nutrition balance, basic healthcare, adjusted herd size,…) has to be well introduced in the farm practices.</td></tr>
<tr><td colspan="2">Entry point 8:
Group dynamics need to be implemented by each program or project to teach people the idea/concept of shifting personal interest to general interest. Such a mental change is becoming urgent due to the population growth and resource disappearance of today.</td></tr>
</table>

Table 16: Summary of the 8 entry points impacts on the 2 objectives to meet.

Entry points 1 to 4 need implementation and support by the government, entry points 5 to 7 can be promoted by extension agents and NGO projects like the project IPMS already does. Entry point 8 is overlapping all other points with the objective to amplify their impact by teaching groups the efficient dynamics and the advantages of working for the general interest in a context of a dense population.

Agricultural techniques are already mostly known and proven as efficient. Therefore social sciences have to be involved to find better social paths for the implementation of more efficient technical solutions. Some questions remain open like (for example):

1. What are the main motivators or interests of both farmers and merchants and what is their hierarchy?
2. How far is the gender issue determining the application of a technique?
3. What are the relations between farmers and the Church and where are entry points to associate the Church in strategies of saving the resources?
4. What are the components of group dynamics and how to gather the required conditions for a self starting dynamic?

Unlocking social mentality will certainly multiply the actual NGOs' work and contribute to the changes, which are necessary to be faster achieved before the resources are more destroyed.

6. Conclusion

Despite some problems to adapt RISE to the conditions of Ethiopia, which lead to acquiring some unreliable data for some of the topics, RISE first study in Ethiopia was able to identify some important failures in their farming management and enabled suggestions for improvement.

These failures are outlined below: there is no energy burned for agricultural purposes but Eucalyptus trees are grown and dung cakes are used as household fuel, disturbing the nutrient balance. Farmers perceive water quantity and quality as positive whereas livestock enter water bodies, decreasing its quality. Water productivity for crops is low due to low yields. Nutrients are available from livestock but high losses due to absent manure storage facilities and high cultivation intensity, together with soil erosion explain the low yields. pH is low (4.2 to 5.0 near households). Poor measures to control erosion and low soil cover miss to protect the surface and thus lower the water productivity for crops. In addition to livestock entering water bodies and clothing being washed in the rivers, run-off dramatically increases river pollution, threatening human and livestock health.

Crop rotation is poor and biodiversity is virtually absent, leading to poor plant protection. The farmers who irrigate their fields are unable to apply the correct amount of water due to lack of knowledge and high pressure on the available water resource. There is evidence of asphyxia below tillage depth in their plots. The number of affordable seed varieties is insufficient to control or prevent pest infestation. Pesticides are not used in large quantities and are safely employed. Those spraying them, however, do not know the thresholds. Only very small amounts of waste are produced but the disposal of batteries and use of antibiotics have been identified as being hazardous.

The national economic situation is difficult and farmers show a very low economic efficiency indicator. Low incomes from market produce, together with high inflation that is still increasing in 2008, lead to insufficient security to take out debt. As a consequence, investment is low and raw performance poor, leading to low returns on assets and equities. As a result of this dynamic spiral of poverty, farmers are unwilling to take risks, resulting in monoculture. This factor creates high variation in quantities available on the market and negatively destabilises prices resulting in lower margins.

Working time is assessed as being low, child labour is important but does not affect school attendance and children’s health. Vocational training is more or less available but farmers seem to find it difficult to attend these courses. Social security is very low and indicates that incomes and assets must increase to enable higher productivity.

In summary, the average economic efficiency indicator is situated at -60 (scale ranging from +100 to -100) and the social security indicator at -27, whereas all other indicators vary between 0 and 40. They are not lower because of the following factors, amongst others: farmers use very small amounts of water for agricultural purposes, the soil is potentially still good, only small amounts of chemicals are used, there is little waste and human resistance- and adaptation faculties are high. In general, there are no grave errors being committed, but nothing is done to fight the slow and inescapable degradation of resources.

As a result of the basic analysis of these results, some techniques that can be applied at farm level have been proposed and discussed with farmers. All these practical suggestions were already known. Informal interviews identified 3 entry points at a higher level to unlock the situation:

1. Land consolidation to avoid scattered plots, reinvestment of the effort gained by efficiently applying good, basic techniques that are already known, together with new ones.
2. Use of social channels for managing common grazing land to stop the formation of gullies and increase fodder productivity of these large areas…
3. Price guarantee to stimulate the motivation of farmers and secure the economical framework. This would encourage investment and innovation and would improve the competitiveness and profitability of the farming systems.

To support efficient implementation of these solutions and to meet the 2 objectives of increasing water- and livestock productivity that results in improving farmers' livelihoods, the following additional entry points are being proposed:

4. Development of water storage facilities and, more importantly, irrigation systems and their association for management, to preserve water quality, reduce water shortage during the dry period and enable a fair distribution of water resources to crop/fodder and livestock producers.
5. Change in cultivation techniques (cover, weed control, no tillage application,…) and crop rotation habits (intercropping, diversification,…) to increase soil cover, and to reduce erosion and losses in soil fertility.
6. Techniques of fodder production (on site, by-products, residues, hay, silage, storage,…) has to be well introduced in the farm practices.
7. Herd management (nutritional balance, basic healthcare, herd size,…) must be part of usual farm practices.
8. Implementation of group dynamics for each program or project to teach people the advantages of forgoing personal interest for the common good. This is of particular urgency due to population growth and resource disappearance.

The focus of this bachelor study is the holistic view provided by the RISE tool. As a result, involvement in real projects is only slight and it contains few precise technical approaches and ways for implementing the three main entry points which could be done by further more specific studies. The thesis outlines also ways of improving the RISE tool (see Appendix 1: Changes and justifications, Appendix 8: Problems encountered and implemented solutions). These, however, do not affect the quality of the RISE analysis or validity of these results.

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Photo 4: Tabe Abay and his familly, Worken PA, 3/26/2008

Appendix

1. Changes and Justifications;
2. Panel 1: Impacts of the farmers' scattered plots on farming management;
3. Panel 2: Impacts of the actual communal free grazing management on resources;
4. Panel 3: Impacts of the market situation on farming management;
5. Impacts assessment of entry points on RISE indicators;
6. RISE improved questionnaire (version 1.5) with exemplar of Product Flow grid and farm drawing scanned;
7. Procedures and Calculation;
8. Queries on encountered problems and implemented solutions;
9. List of the data in pdf;
10. Exemple of a file with RISE results in pdf format
11. CD-ROM containing:
    a. REadMeFirst text file about organisation of the files and data management;
    b. RISE program and Excel related files;
    c. PowerPoint files of presentations to NGOs, ILRI and SCA;
    d. Rough data in Excel format;
    e. From rough data file declined copies containing analysis and graphics per topic (without explanations);
    f. SPSS files of the few relevant tests;
    g. This thesis in pdf format with the 10 appendix;
    h. The poster A0;
    i. Selection of pictures;
    j. SSC-Stat2, Excel plug-in for designing boxplots.